capita GNP in measuring the level of progress achieved by any country in meeting basic human needs. Since then, the PQLI has been gaining widespread acceptance as an index of development at international level. In a sense this measure bypasses the distributional question. Instead of attempting to measure the dispersion, PQLI attempts to quantify directly the so-called quality of life.

THE PHYSICAL QUALITY OF LIFE INDEX (PQLI)

The PQLI combines infant mortality$^{(im)}$, life expectancy at age one $^{(e1)}$, and literacy$^{(l)}$ into a single composite index that represents a wide range of social conditions such as availability of nutrition and clean water, well-being of expectant mothers, healthy general environment, skill to participate effectively in society and to share the benefits of economic growth. Each of the components is indexed on a scale of 0 (the most unfavourable performance in any country since 1950) to 100 (the best expected performance by the end of this century). For infant mortality, the worst performance was 229 deaths per thousand live births in Gabon, and the best expected by the year 2000 is 7 deaths per thousand live births. For life expectancy at age one, the worst performance was 38 years in Guinea-Bissau, and the best expected by the year 2000 is 77 years. Literacy figures (being percentages) are automatically on a 0 to 100 scale. The composite index, the PQLI, is calculated by averaging the three indexes, giving equal weight to each of them.

THE DISPARITY REDUCTION RATE (DRR)

The concept of Disparity Reduction Rate—designed to measure the rate of progress in meeting essential needs—was introduced in 1978 as a complement to the per capita GNP growth rate. The DRR, which serves as a speedometer for social indicators, measures the rate at which a country is closing the disparity (or gap) between its level of performance in any social indicator and the best performance expected anywhere in the year 2000. The DRR can be applied either to certain key individual social indicators (e.g., life expectancy) or to composite social indicators (e.g , the PQLI).

A country's life expectancy DRR, is measured as the rate at which the gap between its life expectancy and 77 years (the best expected by the year 2000) is narrowing. A disparity in literacy is defined as the difference between a country's literacy at any one time and the 100 per cent expected by many developed countries in the year 2000. For infant mortality, the disparity is defined as the difference between a country's given infant mortality rate and the rate of 7 infant deaths per thousand live births considered to be the best attainable by the end of the century. For the PQLI, the disparity is defined as the gap between a country's PQLI performance and the PQLI of 100 that is the best expected in the year 2000. The DRR for each of these indicators is defined as the rate at which the initial disparity is diminishing.

The PQLI and the DRR (applied either to individual indicators or to a composite index such as the PQLI) can be used to compare progress between countries, within a country (by regions, by states, by socio-economic or social group, or sex and sectors) and over time.

OBJECTIVES

India is a land of diversity. The state of industrialisation, development, per capita GNP and physical well-being differ from state to state, region to region and sector to sector. The GNP is used in India todate as a measure of progress and as a basis of planning. It would be illuminating to inquire into the progress in economic as well as physical well-being of people in different states in India. This study attempts to compute PQLI for different states over different years (as 1951, 1961 and 1971) and to compare these indexes with the estimate of state domestic product.

SOURCES OF DATA

The PQLI could be computed for only 15 states for 1971, 14 states for 1961 and 8 states for 1951 (contrary to our original expectations) as data were not available on component(s) for different states and for different points of time under study.

Data on infant mortality published by vital statistics of India for 1941-51 and 1951-60 were accepted for 1951 and 1961 respectively for the study. Despite the qualitative and quantitative deficiencies[1] they have been made use of as they were comparatively more reliable as compared with the only other source of data

1 The civil registration of births and deaths suffered from deficiency, both qualitatively and quantitatively. There were two distinct reasons for this. One was, some of the registration units spread through out the State failed to send their periodical returns to their State Headquarters, due to varying administrative reasons. Since the annual statements giving various vital rates and demographic characteristics for different administrative units were built up from the periodical returns received at the State Headquarters, all such Statements suffered from the deficiency of incomplete coverage both in terms of periodical returns and registration units. The other reason for deficiency was due to events which went unregistered i.e. due to under-registration. The extent of underregistration varied from State to State and fluctuated between years in the country depending upon the efficiency levels of registration machineries.

viz. the National Sample Survey (NSS)[2]. Statistics for 1971 have been taken from Sample Registration System (SRS)[3] as they were fairly reliable. Infant mortality rates in West Bengal and Bihar for 1971 were computed[4] from data fot 1970 (as they were wanting in 1971) and were drafted to the table for 1971.

Life expectancy is derived from mortality tables and, so, suffer from all deficiencies of infant mortality rates. Data were made use of from the only two sources estimated jointly by Registrar General and Census Commissioner in 1968 and 1979. Data were given by sex and were combined into one unit by taking the simple arithmetic average of both. As data on life expectancy at age one (e_1) were not available, life expectancy at birth (e_0) were used.

Statistics on literacy were taken from the Census and were uniform (in definition, coverage and methdology) for all states and for all the three points of time under the study.

In short, deficiency and uneven qualities of data for different states for 1951 and 1961 have affected the accuracy of the data. To what extent the PQLIs were appreciated/depreciated is not estimable. But a comparison of PQLIs between different states may not be hampered to any considerable extent as the deficiencies point towards the same direction, though with differing degrees. The PQLI computed for 1971 is nearly exact as data on the components are substantially closer to the true figures.

ANALYSIS OF ESTIMATES

Inter-Country Comparison and the DRR

The average PQLI for the 70s for 141 developing countries, was 56. Among the developing countries, the low-income countries (under $300 per capita GNP) registered an average PQLI of 39. India's position was just above this average, but evidently far below her neighbour Sri Lanka (PQLI 83)[5] which was the only country to meet the RIO target[6] of PQLI of 77 out of 48 low-income countries (See Table I). Indonesia (50) and Egypt (46) too scored above the average. They belong to the same low income group. Interestingly, India was on par with some oil rich countries whose social performance lagged far behind the sudden economic boom. Algeria, Iran and Iraq which belong to the upper middle-income group ($ 700-1999 per capita GNP) had low PQLI of 42, 38 and 46 respectively in the same period. Similarly a high-income group ($ 2000 or more per capita GNP) country like Libya registered only a PQLI of 42. An express exception is the case of Kuwait which attained PQLI of 76. Incidently this country happens to be a city state. Hence the high PQLI.

Table I: *GNP and PQLI for Selected Countries (1970)*

	Per capita GNP ($)	PQLI
Low-Income Countries (under $ 300 per capita GNP)	152	39
Afghanistan	110	19
Egypt	280	46
Ethiopia	100	16
India	140	41
Indonesia	170	50
Nigeria	290	25
Pakistan*	170	36
Sri Lanka	130	83
Lower Middle-Income Countries ($ 300—$ 699 per capita GNP)	338	59
Albania	530	76
Cuba	640	86
Ghana	430	31
Korea, Republic of	480	80
Morocco	430	40
Thailand	310	70
Upper Middle-Income Countries ($ 700—$ 1,999 per capita GNP)	1091	67
Algeria	710	42
Argentina	1520	84
Brazil	920	68
Iran	1250	38
Iraq	1160	46
South Africa	1210	48
Yugoslavia	1310	85
High-Income Countries ($ 2000 or more per capita (GNP)	4361	95
Kuwait	11770	76
Libya	4640	42
Sweden	7240	100
United Kingdom	3590	97
United States	6670	96

Source: Communique on Development Issues, No. 32, Table 1,
* Harrison P. A. measure of welfare. *Development Forum*, 1979, 7(7). 3.

2 This source has not proved to be equally reliable due to the effect of non-sampling errors. The sub-sample divergences are generally quite wide at state levels (a state-wise study is attempted here) due to the smallness of sample size.

3 The Sample Registration System (SRS) Started in 1964) is a sort of miniature registration in a small manageable sample, where events are registered as they occur and this is supplemented by a half-yearly house-to-house survey. It has acquired great significance (especially with the implementation of Registration of Births and Deaths Act, 1969) and has come to be recognized as the primary source of fairly reliable vital rates for the country for use both by national and international agencies.

4 Computed by giving percentage weight (according to rural and urban proportion of population in each state in 1971) to each sector and adding them up.

5. This figure is as high as that found in the U.S.A., in 1940.

6. The Tinbergen Report to the Club of Rome entitled "Reshaping the International Order" (RIO) set a national target of PQLI of 77 to be attained by the year 2000. It is in contrast to the PQLI target 100 to be attained by the year 2000.

This picture appears to be consistent with the fact that the distribution of income within these countries is significantly skewed. To put this differently, the common feature of these countries is inequality and this seems to be the cause of the deplorably low levels of living.

India's Disparity Reduction Rate (DRR) for the 70s has been estimated as 1.9 per cent. At this rate India may reach the PQLI of 60 in the year 2000. Life expectancy, infant mortality and literacy DRRs were 2.9 per cent, 2.1 per cent and 0.8 per cent respectively for the same period.

If an average annual DRR of 3.5 per cent were achieved, India would reach PQLI of 71 at the year 2000. Table 2 shows for a selected group of countries, what they can reach by the year 2000, if they have an average annual DRR of 3.5 per cent. The table also shows the DRR needed to reach the RIO target of PQLI of 77. India requires an average annual DRR of 4.6 per cent to reach the same.

Table II : *DRR Needed to Reach (Year 2000) PQLI Target in Selected Countries*

Country	Current PQLI	Current Disparity	If Annual DRR—3.5% Year 2000 PQLI	If Annual DRR—3.5% Year 2000 Disparity	Year 2000 PQLI target	DRR needed to Reach Year 2000 PQLI target
Mali	14	86	57.0	43.0	77	6.4
Tanzania	27	73	36.0	36.5	77	5.6
Bangladesh	32	68	66.0	34.0	77	5.3
India	41	59	70.5	29.5	77	4.6
Guatemala	54	46	77.0	23.0	77	3.4
Brazil	66	34	83.0	17 0	77	1.9
Philippines	71	29	85.5	14.5	77	1.2
Mexico	75	25	87.5	12.5	77	0.4
Korea, Republic of	82	18	91.0	9.0	77	*
Jamaica	85	15	92.5	7.5	77	*
United States	95	5	97.5	2.5	77	*
Sweden	97	3	98.5	1.5	77	*

Source. International Development Review, 1979, 21(1), 16.
* These countries have already achieved the RIO target.

It would be particularly interesting to compare the DRR when applied to PQLI with average annual per capita GNP growth rate (See Table 3). India's PQLI escalated from 31 in 1961 to 41 in 1971 resulting in an average annual DRR of 1.6 per cent. Her per capita GNP growth rate was 1.3 per cent annually during the same period. On the other hand, Sri Lanka's PQLI went up from 75 in 1960 to 80 in 1970 registering an average annual DRR of 3.5 per cent. Yet her per capita GNP growth rate was much slower, as low as 1.5 per cent. Other countries were able to achieve a more balanced pattern of rapid progress in both GNP as well as PQLI.

Table III : *International Comparision of PQLI & GNP Indicators*

	PQLI 1960	PQLI 1970	Average Annual DRR (%)	Per capita GNP growth rate per annum (%)
India	31	41	1.6	1.3*
Pakistan	35	36	0.2	2.4
Brazil	63	66	0.8	2.4
Rupublic of Korea	51	76	5.0	6.8
Sri Lanka	75	80	3.2	1.5
Poland	85	92	5.1	5.2

Source : Communique 1979/4, Table 3, Page 3.
*Economic Survey. 1979-80, Table 1.1, Page 75.

In a nutshell, India's achievements in physical well-being of her masses were as poor as her economic performance.

Comparison Between States Within India

The PQLIs of all India in 1951, 1961 and 1971 have been estimated as 14, 31 and 41 respectively with the usual caveat on the uneven-quality and deficiency of data on different indicators between states and between different points of time (See Table 4). The rate of growth in PQLI between 1951 and 1961 is found to be 12.6 per cent whereas it was only 30 per cent between 1961 and 1971. It reflects the historical experience that, in contrast to GNP, the average rate of improvement in life expectancy, infant mortality, literacy and PQLI diminishes as a country gets developed.

Eleven states out of fifteen fall in the PQLI range of 40 50 which cluster around the all India average of 41 in 1971. Uttar Pradesh recorded the lowest PQLI of 31. Kerala (PQLI 66) topped the list par excellence. It was higher by 32 per cent compared to the next highest position of Punjab. In short, deviations of PQLI from all-India average for majority of the states were not notable but for two cases.

Table IV : Social Indicators of States in India (1951-1971)

Country	Expectancy of life at birth (1) (years)			Infant mortality (2) (Death per 1000 live births			Literacy (3) (percentages)			PQLI		
	1951	1961	1971	1951	1961	1971	1951	1961	1971	1951	1961	1971
Andhra Pradesh	*	44.4	54.0	NA	111	106	*	24.6	24.6	NA	31	40
Assam	36.8	44.3	53.9	202	184	139[b]	18.3	33.0	28.7	9	23	37
Bihar	37.6	45.7	54.7	221	145	103	12.2	21.8	19.9	5	26	40
Gujarat	*	*	55.4	NA	NA	144	*	*	35.8	NA	NA	40
Haryana	NA	47.0	51.2	NA	110[a]	72	*	24.9	26.9	NA	34	44
Karnataka	*	47.0	55.6	NA	120	95	*	29.8	31.5	NA	34	46
Kerala	48.3	54.3	61.9	153	120	58	40.7	55.1	60.4	34	49	66
Madhya Pradesh	*	47.4	56.0	NA	175	135	*	20.2	22.1	NA	23	37
Maharashtra	45.2	51.2	58.8	208	109	105	20.9	35.1	39.2	16	41	50
Orissa	*	47.7	56.3	NA	159	127	*	25.2	26.2	NA	27	40
Punjab	*	53.5	61.1	NA	110	102	*	31.5	33.7	NA	42	50
Rajasthan	*	52.8	60.4	NA	177	121	*	18.1	19.1	NA	27	42
Tamil Nadu	39.8	46.1	55.2	202	109	113	20.8	36.4	39.5	13	37	45
Uttar Pradesh	38.9	45 7	54.3	210	186	167	10.8	20.7	21.7	7	20	31
West Bengal	44.3	50.3	57.9	147	120	101	24.0	34.5	33.2	26	38	47
All India	41.3	48.1	56.7	192	140	129	16.6	28.3	29.4	14	31	41

Sources :

1. For 1951, 1961 and 1971. Report on the population projections worked out under the guidance of the Expert Committee set up by the Planning Commission under the Chairmanship of the Registrar General, 1968.
2. Statistical Abstract, India,

* : In spite of availability figures have not been entered here due to unavailability of corresponding figures in other indicator(s).
(a) : Equaled to infant mortality rate of Punjab (b) : Including Meghalaya.

As mentioned earlier, the state of Kerala stood at the top in 1951, 1961 and 1971 in spite of the fact that her average per capita income was always below that of the all India level. The pace of social transformation has been faster than that of economic progress.

In this context, it will be interesting to investigate whether PQLI is related to GNP. To do it systematically, Spearman's rank correlation is calculated[7] for 1971. (See Table 5). The result shows a high degree of correlation between PQLI and the level of per capita

7. Using directly the values of PQLI and per capita SDP as presented in column 2 & 3 of Table 5 the product-moment coefficient of correlation was calculated and it was found to be 0.6. This is a significant at 5% level.

Table V : *Ranking of States according to their levels of PQLI and Income per capita*

(1)	PQLI 1971 (2)	Per capita SDP 1970-71* (3)	Banking of PQLI (4)	Ranking of State income per capita (5)	(4)—(5) (6)	d^2 (7)
Andhra Pradesh	40	578	8	7	1	1
Assam	37	517	9	11	—2	4
Bihar	40	403	8	15	—7	49
Gujarat	40	782	8	4	4	16
Haryana	44	861	6	2	4	16
Karnataka	46	522	4	10	—6	36
Kerala	66	566	1	8	—7	49
Madhya Pradesh	37	500	9	13	—4	16
Maharashtra	50	797	2	3	—1	1
Orissa	40	490	8	14	—6	36
Punjab	50	984	2	1	1	1
Rajasthan	42	560	7	9	—2	4
Tamil Nadu	45	585	5	6	—1	1
Uttar Pradesh	31	504	10	12	—2	4
West Bengal	47	747	3	5	—2	4

n=15

$\Sigma d^2 = 238$

* RBI Bulletin 1978, 32(4), 282.

GNP. The coefficient of correlation arrived at between PQLI and the level of GNP suggests that both the indicators tell the same story.

However, there are some exceptions. The prominent ones are Gujarat and Kerala. Gujarat considered to be quite affluent as assessed by her capita income ranked 12th in PQLI in 1971. Kerala's case was the reverse. Bihar, Karnataka and Haryana too show a different pattern (in terms of the difference in their rankings to GNP and PQLI). Barring the major exceptions which might be arising from widely differing income-distribution, there is a fairly high degree of concordance between the measures of PQLI and income per capita.

Male-Female PQLIs in India

The PQLI, unlike the conventional GNP measure, can compare changes over time, between countries and within countries viz,, inter-region, inter-state, inter-caste/tribe, inter-sector (rural urban) and inter-sex (male-female). Many of the development pron grammes directed towards satisfying basic human needs are focussed on women. So, the PQLI can serve as a measure of conditions of women in all settings and their changing status. The conditions of women especially in literacy will have a definite effect upon the society. Hence the importance of assessment of their progress.

Of the 73 countries studied by Morris (1979) there are 28 in which female PQLI was lower than the male in one or more years between 1949 and 1972. Female literacy rate was somewhat lower in 66 of the 73 countries. Female performance in other two indicators viz., expectancy of life and infant morality rate, is partially better than male performance Women have, generally, longer average life spans and higher survival rates.

Table 6 offers data for 1961 for the states of India. Among the states, the performance varies greatly for both men and women, In all states men have an edge over women in PQLI. Women fare better or no worse in infant mortality rate though it is worse in the other two indicators. Kerala tops all states in respect of male and female PQLIs. In Kerala, women fare much better than men and women in all other states. Orissa and Tamil Nadu show the highest difference (13%) between female-male PQLIs followed by W. Bengal (12%)

In 1970, India happened to be the only country for which all three indicators registered worse performance for women than for men. (See Table 7). This does not mean that the PQLI of women has been worsening. However, the gulf between female-male PQLI has increased from 7 to 10 per cent between 1949 and 1970. Among the individual components, it is literacy which keeps the female PQLI behind the male's. The difference in literacy rate between female and male in 1970 was 23 per cent whereas it was only 2 and 3 per cents respectively in the case of life expectancy and infant mortality rate.

Table VI : *Female and Male PQLI Comparisons in India, by State, 1961*

States	PQLI			Life Expectancy at age one (year)		Infant Mortalily (per 1000 live births)		Literacy (%)	
	Female	Male	Female-Male	Female	Male	Female	Male	Female	Male
Andhra Pradesh	21	29	—8	42.2	43.2	135	145	11.9	35.6
Assam	19	25	—6	41.1	45.4	161	207	15.8	45.3
Bihar	18	25	—8	43.1	44.4	151	170	6.7	35.6
Gujarat	27	37	—10	44.5	45.8	132	136	19.8	49.8
Jammu & Kashmir	18	24	—6	40.3	43.8	133	162	4.2	28.2
Karnataka (Mysore)	26	35	—9	43.1	46.3	113	137	13.8	43 5
Kerala	46	55	—9	53.2	54.0	110	110	44.0	70.4
Madhya Pradesh	18	21	—3	45.4	48.3	166	182	6.4	14.8
Maharashtra	31	42	—11	49.5	51.3	128	139	16.5	50.7
Orissa	10	33	—13	46.5	47.9	159	159	7.9	41.9
Punjab	33	44	—11	52.2	55.0	120	120	14.0	38.4
Rajasthan	28	38	—10	48.8	53.1	115	120	5.9	27.4
Tamil Nadu	25	38	—13	42.7	45.6	124	135	16.8	51.9
Uttar Pradesh	16	25	—9	44.7	47.7	175	190	7.3	32.2
West Bengal	32	44	—12	48.8	49.8	120	120	19.4	51.3
All India	24	34	—10	45.5	47.8	140	153	13.2	41.5

Table VII : *Male and Female PQLIs for India, 1950-1970*

	Male	Female	Total	Difference (Female-Male)	Average Annual DRR		Expectancy of Life at Age One (Years)		Infant Mortality (per 1000 live births)		Literacy (%)	
					Male	Female	Male	Female	Male	Female	Male	Female
1949	17	10	14	—7			39 0	37.3	190.0	175.0	29.4	8.4
1961	24	34	29	—10			47.8	45.5	153.0	140.0	41.4	13.2
1970	45	35	40	—10	1.9	1.5	55.3	54.3	131 0	138.0	45.3	21.5

The average annual DRR of India between 1949-70 was 1.7 per cent. The female DRR registered was a low 1.5 per cent against the male 1.9 per cent.

It may seem that raising female literacy rate to the level of male could change female-male PQLI imbalances in India. Of course, it might help but only to some extent and not dramatically as this individual indicator affects the total PQLI by only one third its absolute value. Nevertheless, as the linkage of female literacy with other indicators is very high, it is bound to affect the PQLI in the long run.

CONCLUDING REMARKS

The limitations of this study should be kept in view while drawing conclusions.

The data on different components of PQLI suffer from severe limitations of uneven quality and availability between states and different points of time in the study. The root cause for this weakness can be attributed to the poor registration system which existed in India. But data for 1971 are relatively more reliable.

As data on life expectancy at age one was not available, life expectancy at birth was used. This has resulted in a slightly lower PQLI.

India being predominently rural in structure, it would be useful to evolve PQLI and DRR for rural and urban sectors separately. But this could not be carried out due to paucity of data. The PQLI for rural sector might be as high as that of a developed country. A fast pace of growth of PQLI or DRR is not possible in India unless and until it starts from the grass-roots viz., the rural sector.

It would be worth while to look into the reasons for Kerala's unique achievement in PQLI despite her poor perfermance in per capita GNP. It is a well known fact that in Kerala distribution of wealth, income and consumption expenditure are not extremely skewed as in many other states. It has improved the standard of living of the masses in general. Even though the gain in income may be below the national average, there has been a more equitable sharing of the total gain.

Kerala has been blessed with high literacy rate for decades. Education is an end as well as a means towards greater social welfare. It is a means as it makes one aware of his rights, creates an urge in him for social and economic change, and leads to a better life for him and his progeny. The relatively highly developed rural sector of Kerala is an indicator of this economic and social transformation. This sector especially gave Kerala an edge over other states in PQLI. There is now hardly a clear-cut differentiation between the rural and the urban sectors of Kerala.

In contrast to Kerala, India has an extremely symmetical pattern of distribution of wealth. The gap between rich and poor, rural and urban is substantial for India as a whole. An alarmingly large slice of wealth and income in India is in the hands of a very few. Better distribution of income primarily and more investment on improvement of 'basic needs' are the needs of the hour.

GNP is an average (in the sense of arithmetic mean) and conceals huge inequalities between rich and poor. An average is a true representative only when the distribution is symmetrical. In India, as distribution of wealth and income is extremely skewed, this measure fails to be a representative parameter of progress. This is, in fact, the major flaw of GNP measure. The same flaw holds good for the PQLI to the extent that it is also an average. In other words, the PQLI like GNP is a measure of central tendency which is an accumulation-index. It fails to throw light on the distribution aspect of the economy which could be the most probable explanation behind the much talked about high social accomplishment of Kerala and Sri Lanks. In short, it is a distribution-Index (dispersion) rather than an accumulation-index (central tendency) like GNP or PQLI that would serve as a true measure of development in developing countries.

Given the degree of concentration in income and wealth, it is clear how the PQLI can just give as much (parametric) information as the GNP does, and nothing more. To the extent this is true, it follows that PQLI cannot serve as a more useful measure than the conventional GNP measure. Any good indicator of the concentration of income and wealth will be a useful measure to supplement the conventional measures. Further research to inquire into the performance of the new PQLI measure under a variety of conditions would appear to be necessary before applying this measure for framing development policy. Our research has only served to raises some doubts with regard to the validity of the PQLI measure for India's development policy. It remains to be seen how PQLI can serve as a reliable and useful guideline for shaping development policies in the future.

REFERENCES

Bhattacharjee P J & Shastri G N. *Population in India*, New Delhi ; Vikas, 1979, 85 p.

Chandra Sekhar S. *Population Growth and Family Planning in India*. London : George Allen Unwin, 1972, 76 p.

Grant J.P. Central issues in the North-South dialogue. *The OECD Observer*, 1969, No. 96, 3-5.

Grant, J.P. A new speedometer to track social progress. *International Development Review*, 1979, 21(1), 13-17.

Greentree T R & Philips R. The PQLI and the DRR, New tools for measuring development progress. *Communique*. 1979/4.

Jain S P. State growth rate and their compoments, in Bose, A (ed). *Pattern of population change in India: 1951-61*. Calcutta: Allied Publishers, 1967, 397 p.

Mitra A. *India's population. Aspects of quality and control Vol. I*. New Delhi : Abhinav Publications, 1978. 496p.

Morris, M D. Measuring the condition of the World's poor: The Physical Quality of Life Index, ODC, New York, 1979.

Morris D M & Liser F B. The PQLI : Measuring progress in meeting human needs. *Communique and Development Issues*, 1979, No. 32.

Thomas V. K. PQLI and the DRR : Indicators of development progress. *Sendoc Bulietin II*, 1980, 8(2), 1-17.

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EXECUTIVE READINGS*

Working Life : A Social Science Contribution to Work Reform.

By Gardell, B and Johansson. G. (Eds)
New York : John Wiley & Sons, 1981.

The purpose of this book is to give a broad understanding of the conditions of the working man in Western societies and the consequences of these conditions for the individual, his health and social relations.

The book is divided into five parts, with an introduction by Bertil Gardell on "Strategies for Reform Programmes on Work Organisations and Work Environment". Part 1 : "Psychological Effects of Advanced Technology" has chapters on "Work and Health Some Psychological Effects on Advanced Technology" "Chronic Effects from the Physical Nature of Work", "Metallurgy in a Social Context". Part 2 : "The Time Aspect of Production Systems : the Work-Leisure Relation" covers such subjects as "Job Socialisation and Job Strain", "Time Aspects of Production and Reproduction" and "The Work-Leisure Relationship under Changing Economic Conditions and Societal Values". Part 3 is devoted to the 'Social Effects of a Changing Labour Market'; Part 4 : "Quality of Life in Industrial Society", ; and Part 5 : "The Role of Social Science in Working Life Policy". Each part is accompanied by discussants comments, and each chapter gives references, some of them extensive. □

A Factory Organised in Work Groups : An Evaluation by Different Parties

By Misrahi M. and Trepo G.
Fance: Centre d'Enseignement Superieur des Affaires, 1981

This 120 page report provides a full description of changes in work organisation in a nylon yarn factory. It begins by giving theoretical aspects of work organisation and goes on to describe the factory, the work methods and how the research was carried out. Evaluation of the changes in work organisation is provided from the perspectives of the workers themselves, the management, and the service functions concerned. A further chapter considers the implications for trade unions of the new work methods. □

Women on the Job

By Agassi, J.B.
London: Lexington Books (distributed by Grover Publishing Co.), 1980

This book is an analysis of three women's occupational groups in the United States, West Germany and Israel with respect to job characteristics and attitudes. Much of the work is devoted to examining society's assumptions about the jobs women perform, and exploring the relationship between women's work experience and expectations for job reward and advancement. □

Technology Change and Its Manpower Implications

By Bradbury, F. and Russell, J.
Middlesex : J. Russell, 1980

This research paper is the result of an international investigation

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into technological change in the chemical and allied products industries of Japan, the United States and the United Kingdom. The research, which involved a series of interviews with top management of compnaies in seven major sectors of the chemical industry, is divided into four parts. The first three are devoted to the kind of technological change that has taken place within the sectors concerned ; the fourth part deals with the demands of technology and the expectations of people. The authors' research confirms that the crucial factor in improving productivity is to increase employee motivation and attitude to work, and argues strongly for a more integrated approach to people and technology. They urge that special attention be given to creating new working arrangements, managing organisational change, and developing both employment and training policies. □

"The Quality of Life"

Sage Studies in International Sociology, Vol. 20

By Szalai, A. and Andrews F.M. eds. (1980)

London : Sage Publication, 1980

The editors, who come from the Hungarian Academy of Sciences, Budapest and Institute of Social Research, University of Michigan respectively, have made a collection of studies which define, measure, and compare the quality of life in different countries and in different periods of history. Authors from fourteen countries present empirical research, discuss theoretical issues and describe the state of this new specialisation. □

Staff Burnout

Job Stress in the Human Services By Cherniss, C.

Sage Studies in Community Mental Health Vol. 2

London : Sage Publications 1980

Burnout—the reaction to stress in one's job, characterised by exhaustion. depression, and disengagement has long been a problem in organisations, particularly those that deliver social services. In this book the author finds the roots of burnout in the individual, the work setting and in the larger society. He examines its dynamics and suggests some concrete preventive measures. Over twenty different intervention strategies are identified and illustrated with examples. Basic approaches include staff development and counselling programmes, redesign of staff roles, management development programmes for supervisory and administrative personnel, and careful development of programme goals and guiding philosophies. He also presents case studies of burnout, contrasting effective and ineffective work settings. □

The Third Wave

By Toffler, A
London, Collins, 1980

The theme of this book is that all seemingly senseless events—such as inflation, the rise of terrorism and the creation of new work, play and family patterns—are not erratic, unconnected and random. They are part of a pattern of a much larger phenomenon—the death of industrialisation and the rise of a new culture.

Three major 'waves' are seen in the development of mankind: the invention of agriculture 10,000 years ago; the industrial revolution; and the microelectronics era, leading towards a new 'technostructure'. Toffler's thesis is that the second 'wave' created division of labour, and centralisation of authority, not only in work situations but also in areas like the family, where the man was the producer and the woman the consumer, in education, health, leisure, etc. This in turn led to standardised media, education, shopping facilities, etc.

He goes on to explore various areas of life which will be affected by the new technology all of which mean that the producer and the consumer will no longer be divorced from each other. There is likely to be less standardisation and greater scope for individual freedom. Some of the topics he looks at in the context of the third 'wave' are various forms of media, the electronic cottage, family structure, consumerism and batch production, office technology, new forms of energy and their impact on less developed countries, the growth of communities and new political structures. □

Putting Participation into Practice

By Guest, D. and Knight, K.
England : Gower Publishing Co., 1979

The editors of this book, Guest and Knight, have collected detailed case histories of the various approaches towards a more participative mode of decision-making and operating at the workplace, adopted at shop floor, plant and company level, written by the people involved. The individual case histories are supplemented by comprehensive reviews of deve-

lopments at each level of participation and by a more general examination of the implications and problem of implementing these systems. The editors contribute a descriptive and analytic framework which clarifies the origins of the growth of interest in the subject, the attitude surrounding it and the different forms participation can take. □

Educational Paradigms

An Epistemological Revolution
By Fred Emery (1980)

Our methods of education are based in Emery's view on a Lockean—'Newtonian' view of the world.

The core of the traditional educational paradigm lies in epistemology, not in educational practice. And this epistemology is essentially associationist. Its aim is the critical, disciplined and literate mind.

	Traditional Paradigm	The Ecological Paradigm
A. The Practice		
Object of learning	transmission of existing knowledge abstraction of generic concepts	perception of invariants discovery of serial concepts discovery of universals in particulars.
Control of learning	asymmetrical dependence teacher-pupil competition of pupils	symmetrical dependence co-learners cooperation of learners.
Coordination of learning	Schools/classrooms age-grading/ school	community settings synchronized to and negotiated with community settings.
a) behaviour setting	calendar	
b) timing	class timetable	
learning materials	text books standarized lab experiments	reality centre projects.
learning activity	paying attention rote practice memorizing	discrimination differentiation searching creating
teaching activity	lecturing demonstrating	creating and re-creating learning settings.
system principle (after Abrahms, 1953)	pedagoguery "the mirror"	discovery "the lamp"
B. The Experience		
Cultural mode	work/religion 'serious drudgery'	active leisure 'exciting, frustrating'
dominant group emotions (after Bion 1961)	dependency fight-flight	pairing
personal development	conformity-bullying-divorce of means and ends-cheating-self-centredness hatred of learning (and swots)	tolerence of individuality depth and integration homonomy learning as living. □

The revolt against the old paradigm culminates in Gibson's ecological view of perception wherein the environment has in infrastructure to extract that information from which our perceptual system have evolved.

The new epistemology differs from the traditional:

Traditional Paradigm	*New Paradigm*
abstraction	extraction
generic concepts	serial concepts
permanence-change	relative persistence
achieved by thinking and memory	achieved by perceptual activity.

Hitherto, we have conceived of education as a filling up of minds with information and training, where suitable, in the logic of abstraction and inference. We are now confronted with the fact that people are equipped to directly achieve information for themselves and they achieve that in conceptual form-the same form of serial concept that stands as the highest achievement of modern science. The central problem for education is no longer which minds can achieve conceptual knowledge and undertake conceptual operations. In the new paradigm the central question is what kinds of evironments best enable all minds to exercise their ability to perceive deeper orders of invariance.

Drawing on many sources, from Heider and Cassirer to Chomsky and De Bono, Emery argues that learning to learn, in adults as in children, requires a new paradigm. His Search Conferences and Development of Human Resources Workshops are characteristic of the New paradigm.

Emery summarises his contrast of the old new as follows:

Job Profiles : Method of Analysis of Working Conditions

By A. Lucas,
Masson : Paris, 1976

In the preface to this work the author explains that the "method of 'Job Profiles' has been developed for the same reasons as the 'Ergonomic Aide-memoire' which we (Renault) published in 1974, from the industrial experience of twenty years and from continual consultations between specialists on working conditions and production. It offers precisely the advantage of allowing technicians in methods departments and production units, as well as the specialists in working conditions themselves, to have a better appreciation of the quality of the installations already operating or simply being designed with regard to the abilities and the expectations of the men who are to work there...'Job Profiles' is of value only as a tool. It will be of use and significances only in the service of a policy on working conditions and a concept of organisation inspired by a far-sighted view of the firm"

European Foundation for the Improvement of Living and Working Conditions

"Training and the Organisation of Work" : The volume consists of an evaluation report of the employers group as a results of a seminar on "Training and New Forms of Work Organisation", held in Dublin last year ; and six national case studies on "The Role of Training in the Introduction of New Forms of Work Organisation". The case studies, in the order in which they are presented, are taken from the United Kingdom, Belgium Italy, Netherlands, France and the Federal Republic of Germany. These are followed by a "Synthesis Report".

"The Analysis of Changes in Work Organisation" covers a series of research projects carried out in the United Kingdom, Federal Republic of Germany, Netherlands, Italy and France : and a report on a seminar on "The Foundation Model" both for the trade Unions' group and the employers' group, held in Dublin in September, 1979. The projects were carried out in these five EEC countries in order to test the analysis model for monitoring new forms of work organisation. The studies present experiments in reorganisation of work, described and analysed on the basis of the model.

"Economic Aspects of Shift Work". This volume contains the results of a research project commissioned by the European Foundation in Dublin concerning some economic aspects of shiftwork. The research consisted of : an inventory and an evaluation of the costs of shiftwork incurred by the enterprise and the community in general ; and an examination of the probable trends in these costs. This is followed by an evaluation of the nature of the technical/economic constraints involved and a definition of the scope for improvement of living and working conditions offered by different kinds of shiftwork organisation. □

Information Technology in the Office : The Impact on Women's Jobs

By Emma Bird,
Manchester : Equal Opportunities Commission, 1980

The conclusions of this report indicate a seventeen per cent displacement of office jobs in the U.K. by new technology. It also sees a more rapid shrinking of unskilled and semi-skilled clerical jobs than secretarial and typing jobs. Miss Bird also provides information concerning job satisfaction, training and career progression. □

The Study of Organisations : Findings from Field and Laboratory

By Katz, D., Kahn, R.L. and Adams, J.S. (Eds)
London : Jossey-Bass, 1980

This book draws together in one volume a broad selection of the major research in the study of organisations. The thirty-eight papers have been chosen because they clearly demonstrate how complex organisational problems can be studied successfully in both natural and laboratory settings ; among these are the classic laboratory, simulated work environments, public educational and health institutions, and mulii-plant industries. The methods employed include survey questionnaires, participant observation, archival search, and biomedical assey. They book is divided into eight parts, with an introductory and concluding commentary by the editors, as well as essays introducing each of the parts in which the selections have been grouped, and the selections themselves represent a wide array of research settings and methods. □

Productivity
1982, XXII, 4, 109-113

Quality of Working Life and Productivity—The Australian Approach

LYNDON CRICK

The paper looks at the approach taken by the Productivity Promotion Council of Australia to the raising of awareness in the community of the link between improving quality of worklife and improving productivity. It identifies four key quality of worklife areas—workplace design, technological change, multi-cultural workforces and manpower planning—and brings out the interactive nature of the issues subsumed in those areas.

Mr. Lyndon Crick is presently Acting Executive Director with the Productivity Promotion Council of Australia at Melbourne. He is responsible for the human resources and workplace design programmes of the Council.

Productivity Promotion Council of Australia has long recognised that the quality of work life—the environment, the conditions and the organisational culture in which employees work is critical to productivity improvement. It is the intention of this article to review PPCA's current approach to upgrading awareness in Australian industry of that critical link and to promoting improvement in Australian employees' quality of working life.

As background to that review it is necessary to look at earlier work of PPCA, specifically in the period 1973-76, as it forms the basis on which PPCA's current approach is founded. In that period PPCA adopted as its theme "People and Productivity" with the aim of promoting awareness throughout the community of the paramount role of people (those who work at everyday jobs as well as those who direct and manage industry and commerce and the economy) and quality of working life issues in productivity improvement in modern industrial society. This effort was pursued through two inter-related strategies.

The first of these was a large-scale, wide-focus community awareness programme aimed at bringing to the attention of every Australian the meaning of productivity, how productivity was increased, who was responsible for increasing productivity and the benefits of productivity improvement.

The second strategy was to promote the use of the organisation development concept in industry and commerce as one which offered considerable potential for improvements in productivity and in the quality of working life of employees. Through its promotion of the concept PPCA became a leader in the application of the principles of industrial democracy and brought wide recognition of the right of employees to meaningful

participation and satisfaction in working life and to the importance of communication between management and labour.

PPCA's activities in this initial stage were predominately aimed at information dissemination and concept promotion. PPCA's concern in promoting the organisation development concept was to go beyond the usual understanding of improving the quality of working life, that is attention to improving physical working conditions and developing good personnel practices, to advanced organisational practices which would improve organisational effectiveness and enhance both the individual's sense of their work and their opportunities for personal growth and achievement.

The key elements of organisation development which PPCA stressed in its programmes were :

(1) Job design and development, focussing attention on changing the structure and content of the individual's job, the key principle being that most people are more effective in their work and get more satisfaction if their jobs interest them and offer a challenge.

(2) Team building, design and development, carrying on and expanding a theme of developing the organisation through improving the effectiveness of the work group as an operating team. This placed emphasis on the fact that much of the work in any organisation is accomplished through groups of people rather than through individuals.

(3) Problem solving and planning—drawing attention to the fact that problem solving and planning are not, or ought not to be, the function of managers and supervisors alone.

(4) Developing interpersonal skills through various approaches but emphasising the meeting together of people in 'workshops' together with a 'trainer' who endeavours to facilitate the development of discussion in the group.

(5) Labour-management communication encouraging the establishment of communication as a two-way process in which both parties are engaging and responding to each other.

(6) Employee participation which is the essence of the organisation development concept and the engaging elements listed above.

From 1976 PPCA increasingly oriented itself to furthering its successful promotion of general OD concepts by developing enterprise-level self-help aids which, as well as encompassing the key elements above, were identified as quality of working life issues, the management of which will be crucial to organisational effectiveness in the 1980's and beyond. Whilst defining these issues—work place design, technological change, multi-cultural work forces and manpower planning clearly—PPCA has continually stressed that they are all mutually interdependent and that successful management strategies for organisational effectiveness will need to be fully aware of the interactive nature of the areas identified. At this point it is worth noting PPCA's approach and products in these four key areas :

WORKPLACE DESIGN

PPCA's stress in developing and promoting an expanded concept of workplace design has been that workplace design must be a multi-disciplinary (social sciences, industrial engineering, ergonomics, architecture etc) and multi-partite (management, consultant, employee, union delegate) process leading to a workplace that is effective in terms of both human and organisational needs. Inevitably this led to a concept far beyond the usual environmentalist concept of workplace design as the control of heating and cooling, light and noise. Whilst still important, PPCA's approach sees them as being only part of a much broader range of issues involved in contemporary workplace design including :

* Technological change creating a higher need for planning, particularly in human engineering aspects and worktask/work-process design.
* Worktask/work-process design incorporating industrial engineering practices and sound ergonomic practice as an integral part of task design, attention to job content and team building aspects as well as maximising effective communication systems.
* Safety/housekeeping emphasising the need for their consideration from the *first* stages of workplace design rather than as an afterthought as well as the role of employees in safe working practices.
* Employee involvement in workplace design matters in a meaningful way.

Since 1978 PPCA has mounted a substantial research and development programme leading to an integrated Workplace Design Programme featuring three elements : the Enterprise Self-Help Workplace Design Package, Workplace Design Seminars and the Workplace Design of the Year Award, designed to promote the concept and to provide self-help aids to enterprises wishing to

undertake workplace design or redesign. Each of the elements stresses the multi-disciplinary, multi-partite, self-help principles central to, PPCA's concept.

A description of each element is as follows :

(i) The Enterprise Self-Help Workplace Design Package offers a range of specifically developed PPCA user materials to assist in the design and/or redesign of workplaces to meet productivity and quality of working life criteria including sound industrial design and appropriate industrial engineering and ergonomic principles. Inherent in the development of this package was production of a Workplace Design Audit. This ties together the user materials in the package and through the agency of a checklist provides a starting point for enterprises in the design or redesign of the workplace. All material in the package links with the criteria used in judging for the Workplace Design of the Year Award (see below).

(ii) The PPCA Workplace Design Seminar. This initiative provides a forum where employer and employee representatives together, in one-day seminars, gain greater awareness of : the way to use design principles for achieving productivity improvement ; the role which employees can properly play in decisions relating to improved design of their workplaces ; the self-help materials available and the latest overseas developments.

(iii) The Workplace Design of the Year Award, where enterprises win public recognition for achievements of excellence in workplace design which enhance productivity and quality of work life. The Workplace Design of the Year Award generates widespread awareness of the interrelationship between peoples' jobs and such working conditions considerations as the design of work stations ; the quality of the working environment ; the quality of the product made or services provided in those environments ; and the quality of life at work in the total sense.

In outline the criteria for judging the Award are the design of the workplace (layout and postural factors), design of the work environment (lighting, thermal comfort, etc.), design of the work process (work flow/work methods), occupational safety and health, amenities (personal and recreational facilities) and employee involvement.

All entrants in the Award are given a copy of the Judging Panels confidential report so that they can identify and improve problem areas in their workplaces.

The programme is also of interest internationally since one element, the Workplace of the Year Award, is unique. The only comparable award is a "Factory of the Year Award" conducted by the National Agency for the Improvement of Working Conditions (ANACT) in France. PPCA's Award, however, is not limited to factory design.

TECHNOLOGICAL CHANGE

It is a commonplace, but nonetheless true, statement that the management of technological change will be the issue of the 1980's. It is also true that it will be the most complex issue involving a range of interdependent factors through management of the economy, resource allocation, political implications and socio-cultural impact at national and international levels to communication systems, financial management, imported versus internally developed technology, human resources management and, as we have already seen, workplace design at the enterprise level.

Subsumed in that range of factors are a number of quality of work-life issues which will be directly affected by technological change and which have the potential for greatly improved standards of worklife and organisational effectiveness, or, if badly managed, greatly lowered standards. Amongst these, predominantly but not exclusively needing national rather than enterprise level attention are :

- Employment/unemployment—managing what will be twin trends to considerable employment displacement combined with a shift in the labour market away from traditional skills. It is worth noting here that the precise effect may depend on the approach taken at enterprise level by management to job redesign.
- Socio-cultural Impact—here well conceived government policies on training, education, income support and technological assessment may be necessary to avoid not only the deskilling of jobs to boring, repetitive tasks but also the division of society into the employed and the unemployable.
- National participative planning—the exact socio-cultural impact of technological change will be dependent on the ability of the major interest groups to co-operate and to share information and decision making.

At enterprise level PPCA sees the major quality of work life issues being :

- Workplace design—as already discussed.

Davis, L.E., and Cherns, A.B. *The Quality of Working Life.* New York. The Free Press, 1975.

Davis, Louis E., Taylor, James C., (eds.) *Design of jobs.* Harmondsworth : Penguin Books, 1972, 477 p.

De, Nitish R. Country report on India as a part of the project Comparative study on New Forms of Work Organisation, a report submitted to Conditions of Work and Life Branch Working Conditions and Environment Department, International Labour Office, Geneva, 1976.

Dickson, Paul. *The future of the workplace : the coming revolution in jobs.* New York : Weybright and Talley, 1975. 378 p.

Dubrowski, JN. *The systems of notions of cetegories of scientific work organisation,* Moscow : Economics, 1973. 118 p.

Economic Development Committee for Mechanical Engineering, London. *Why group technology ?* London, 1975. 36 p.

Emery, Fred E. Emery, Messelyn. *A choice of futures.* Leiden : Martinus Nijholf, 1976. 213 p.

Emery, Fred E. Thorsrud, E. *Democracy at work : the report of the Norwegian Industrial Democracy Programme.* Oslo : Tanum Press, 1970.

Fairfield, Roy, P., (ed.). *Humanizing the workplace.* Buffalo, N.Y. : Prometheus Books, 1974. 265 p.

Ford, Rubert N. *Motivation through work itself.* A Report. New York : American Management Association, 1969,

Gardner, Neely D. *Group leadership.* Washington : National Training and Development Service Press, 1974. 41 p.

Glaser, Edward M. *Improving the quality of worklife...and the process, improving productivity.* Los. Angeles : Human Interaction Research Institute, 1976.

Great Britain Department of Employment Work Research Unit. *Improving satisfaction at work by the job redesign.* London : HMSO.

Great Britain Department of Employment Work Research Unit Making work more satisfying. London : HMSO, 1975.

Griew, Stephen. *Job Re-Design.* Paris : Organisation for Economic Co-operation and Development, 1964.

Groeneveld, A. *Job Enrichment ; a Case History.* Den Hagg, 1971.

Hassenkamp, A. *Quality of working conditions, problem and approaches to a solution.* Geneva: International Institute for Labour Studies 1975, 13 p.

Hedberg, M. *Changes in work organisation : summary of trial activities in Sweden.* Stockholm : Swedish Council for Personnel Administration, 1972.

Hieronymus, George H. *Job design : meeting the manpower challenge.* Washington : Society for Personnel Administration, 1958.

Hill, P. *Towards a new philosophy of management.* New York: Barnes and Noble, 1972.

Hopwood, Anthony G. *Towards assessing the economic costs and benefits of new forms of work organisation.* Paper prepared for the International Institute for Labour Studies, Geneva, 1976.

International Christian Union of Business Executives *Quality of life in the business firm : a report of five experiments being carried out in four European countries.* Brussels, 1974, 54 p,

Jenkins, David, ED. *Job reform in Sweden : conclusions from five hundred shop floor projects.* Stockholm : Swedish Employers' Confederation, 1975 130 p.

Katzell, ME. *Productivity : the measure and the myth.* New York : American Management Association, 1975. 38 p.

Klein *New forms of work organisation.* Cambridge, Mass.: Cambridge University Press, 1976. 102 p.

Lampkin, Paul. *Job Enrichment.* Ottawa : Canada Department of Labour, 1975.

Lindosted, H., Norstedt, Jan-peder. *Autonomus groups and payment by results.* Stockholm : SAF, 1973.

Lindholm, Rolf. *Advances in work organisation : four Swedish cases,* Stockholm : Swedish Employers' Confederation, 1973.

Margerison, Charles J. *Managing Effective Work Groups.* London : McGraw-Hill, 1973. 88 p.

Meadows, In S.G. *Innovative work arrangements : a case study in job enrichment.* Canadian Industries Limited—CIL—Paints Division, Vaughan Centre. Toronto, 1974. 16 p.

Myers, M. Secott. *Every employee a manager : more meaningful work through job enrichment.* New York : McGraw-Hill, 1970. 233 p.

Nielsen, PW. *Developing effective worker participation.* Amsterdam : Urwick International Ltd., 1975.

Organisation for Economic Co-Operation & Development. *Prospects for labour/management cooperation in the enterprise.* Final report of a regional joint seminar. Paris, 1974.

Penzer, William N *Productivity and motivation through job engineering.* New York : AMACOM, 1973, 31 p.

Roy, W. Walters. *Job enrichment for results : strategies for successful implementation,* Reading, Mass. : Addison-Wesley Pub,, 1975. 307 p.

Seashore, Stanley E., Marrow. AJ, Bowers DG. *Management by participation.* New York : Harper and Row, 1967.

Skard, Oyvind. *Organisational change and job design.* Co-operation Council of LO NAF., 1975.

Srivastava, Bhupendra K. *Condition and Organisations of Work.* Paper prepared for the National Seminar on Quality of Working Life. Bombay : Central Labour Institute. 1975.

Suojanen, Waino. *Perspectives on job enrichment and Productivity.* Atlanta. School of Business Administration, 1975. 279 p.

Susman, Garald I. *Autonomy at work : a sociotechnical analysis of participative management.* New York : Praeger, 1976.

Taylor, James C. Concepts and problems in studies of the Quality of working life. Los Angeles : University of California 1973. 56 p.

Taylor, James C. Experiments in work system design : economic & human results. Los Angeles : University of California, 1975.

Well, Reinhold. *Alternative work organization . Improvements of labour conditions and productivity in Western Europe.* International Institute for Labour Studies, Research series 4, 1976, 26 p.

B. ARTICLES

Ager, B. Work organization in sawmills : for the individual. In *Proceedings of IUFRO Joint Meeting, Div 3 and 5, Ergonamics in Sawmills and Woodworking Industries, Symposium in Sweden, Aug. 26-30, 1974* Stockholm, Arbetarskydsstyrelsen, 1975, 295-300 pp.

Agersnap, Flemming, Danish experiments with new forms of co-operation on the shopfloor *Personnel Review*, 3, 1974 34-50 pp.

Alderfer, Clayton P. Job enlargement and the organizational context, *Personnel Psychology*, Winter 1969, 418-426 pp.

Anderson. G, The quality of work life : South Australian development. in : *Seminar on Worker Participation in Australia, University of Melbourne, 1975* : *Proceeding*. Parkville, Vic., Dept. of Legal Studies and Industrial Relations Programme, University of Melbourne and Melborne Chamber of Commerce, 1975, 16-24 pp.

Ansari, KA. Industrial relations and productivity *Andhra Pradesh Labour Bulletin*, 2(5), Aug. 1971, 5-9 pp.

Astrop, AW Group technology as a way of life. *Mechinery*, 126 (3241), 1975.

Baldridge, J Victor, & Burnham, A, Organizational innovation : individual, organizational, and environmental impacts. *Administrative Science Quarterly*, 20, June 1975, 165-176 pp.

Banks, Tony, Autonomous work groups. *Industrial Society*. July-August 1974, 10-12 pp.

Bell, D Wallace, The participation debate : a new dimension. *Industrial Participation*, (555), Summer 1974, 9-13 pp.

Bhattacharya, KP, A motion and time study experiment : its usefulness for redesigning work place layouts and observer reliability. *Journal of Psychological Researches* 5, 1961, 63-69 pp.

Birchall, DW & Wild, R, Autonomous work groups. *Journal of General Management*, 2(1), 1974

Bishop, Ronald C & Hill, James W, Effects of job enlargement and job change on contiguous but non-manipulated jobs as a function of worker status. *Journal of Applied Psychology*, 55, 1971, 175-181 pp.

Bjork, Lars, An experiment in work satisfaction. *Scientific American* March. 1975, 17-23 pp.

Budd, M, Employee motivation through job enrichment. *Journal of Systems Management*, 25(8), 1974, 34-38 pp.

Canon, Martin J & Poole, Brian, A, Involuntary job rotation and work behaviour, *Personnel Journal*, June 1972, 446-448 pp.

Carpentier J, Organisational techniques and the humanisation of work. *International Labour Review*, 110 (2), Aug. 1974, 93 p.

Carroll, Archie B. Conceptual foundations of job enrichment. *Public Personnel Management*, Jan.-Feb. 1974, 35-38 pp.

Chatterjee, SK Few thoughts on job evaluation and job enrichment and their problems. *Industrial Relations*, 23 (1). Jan.-Feb. 1971, 18-22 pp.

Clerc, Jean-Marc. Experiments in humanising the organisation of industrial work : some points from a symposium. *International Institute for Labour Studies, Bulletin*, (11), 1975, 15-20 pp.

Conant, E.H. & Kilbridge MD. An interdisciplinary analysis of job enlargement : technology, costs and behavioural implications. *Industrial and Labour Relations Review*, 18, 1965, 355-395 pp

Daniel, WW. Changing hierarchies at work. *Listener*, (7), Sept. 1972, 300-302 pp.

Davis, Louis E. The design of jobs. *Industrial Relations* Oct. 1966, 21 45 pp.

Davis, Louis E. Restructuring jobs in social goals, *Manpower*, Feb. 1970, 2-6 pp.

Davis, Louis E & Taylor, James C. *Technology, Organisation and Job Structure*. Paper Prepared for the International Conference on the Quality of working life, Arden House, New York, August 1972.

Davis, Louis E & Valfer, ES. Intervening responses to changes in supervisor job design. *Occupation Psychology*, 39. 1965, 171-189 pp.

De, Nitish R. Training strategy for required attitudinal change. *National Labour Institute Bulletin*, 1976, 13-28 pp.

De. Nitish R. Work commitment and work ethics in Public enterprises : A framework for consideration. *National Labour Institute Bulletin*, 1(4), Apr. 1975, 13 pp.

Dettelback, WW & Kraft. P. Organization change through job enrichment. *Training & Development Journal* Aug. 1971, 2-6 pp.

Donaldson, Lex Job enlargement : a multidimensional process. *Human Relations*, 28 (7), Sept. 1975, 593-61 pp.

Donnelly, John F. Increasing productivity by involving people in their total job, *Personnel Administration*, 34, Sept.-Oct. 1971, 8-13 pp.

Douglas Merrill E & Johnson, T Stephen. Successful job enrichment : a case example. *Altanta Economic Review*. Nov.-Dec. 1974, 9-12 pp.

Dowling, William F. Job redesign on the assembly line : farewell to blue-collar blues ? *Organisational Dynamics*, Autumn 1973, 51-67 pp.

Duffany, Bruce. Beyond job enrichment. *Journal of Humanistic Management*, 2 (1), 1974, 22-27 pp.

Edgren, Jan. Swedish experiments in work organization. *Personnel Management*. 6, June 1974, 25-27 pp.

Edwards, GAB, Group technology : a technical answer to a social problem ? *Personnel Management*, March 1974, 35-39 pp.

Emery, Fred E & Markak J. Some socio-technical aspects of automation. *Human Relations* 15, 1962, 17-25 pp.

Fazakerley, GM. Group technology. *Production Engineer* Oct. 1974, 383-386 pp.

Fein, Mitchell. Job enrichment : a revaluation. *Sloan Management Review*, Winter 1974, 69-88 pp.

Fein, Mitchell. Job enrichment does not work, *Atlanta Economic Review* Nov.-Dec. 1975, 50-55 pp.

Fein, Mitchell. The myth of job enrichment. *Humanist*, Sept.-Oct. 1973, 30-32 pp.

Foegen, JH. Reading at the work station : job enrichment. *Training & Development Journal*. 29 (2), Feb. 1974, 3-5 pp.

Ford, Robert N. Job enrichment lessons from AT&T. *Harvard Business Review* 51(1), Jan.-Feb. 1973, 96-106 pp.

Frank, LL & Hackman, JR. A failure of job enrichment : the case of the change that wasn't. *Journal of Applied Behavioural Science*, (4), 1975, 413-436 pp.

Charnes, A Cooper, WW. Measuring, Monitoring quality of life. *Management Science*, 19(10). June 1973, 1173, 1172-1189 pp.

Charns, Albert B *Perspectives on the quality of working life.* A paper to the British Sociological Association, 1975.

Chatterjee, Amitava & James, EV An investigation into the problem of effective supervision. *Journal of Indian Academy of Applied Psychology*, 2, 1965, 8-12 pp.

Cherrington, David J. The effects of a central incentive-motivational state on measures of job satisfaction. *Organizational Behaviour and Human Performance*, Oct. 1973 271-289 pp.

Chichester-Clark, Robin. On the quality of working life. *Personnel Management*. Nov. 1973, 26 pp.

Conference on New Concepts of Work Ottowa, Mar. 1973, *Proceedings*, Ottawa 1974.

Conference on Quality of Work Controversy. Chicago, Dec. 9-11, 1973, *Proceedings*, Chicago 1973.

Conference on Work Organisation, Technical Development & Motivation of the Individual, Brussels, 1974.

Background papers. Brussels, Commission of the European Communities, 1974.

Cooper, CL. Humanizing the work place in Europe : an overview of six countries. *Personnel journal* 59(6), June 1980, 488-91 pp.

Crawford, I. Varied working hours in Australia. *Personnel Practice Bulletin*, 30(4), Dec. 1974, 311-320 pp.

Delamotte, Yves. The attitudes of French and Italian trade unions to the 'Humanisation' of work. *Labour and Society*, Jan. 1976, 49-62 pp.

Elbing, Alvar O & Gadon, H Flexible working hours ; the missing link. *California Management Review*, 52, Jan.-Feb. 1974, 18-20 pp.

Economician (Pseud). Strained industrial relations inhibit production at Hindusthan Cables. *Industrial Times*, 14(12), June 1972, 13-15 pp

Ganguli, ON. Humanlsation of work. *Industrial Relations* 31(1), Jan.-Feb. 1979, 23-26 pp.

Gass, JR. Education, work and the quality of life. *The OECD Observer*, (67), Dec. 1973, 6-10 pp.

Glaser, Edward M. Productivity gains through worklife improvement. *Personnel* 57(1), Jan.-Feb. 1980, 71 77 pp.

Guest, Robert H. Quality of work life—learning from Tarrytown. *Harvard Business Review*, 57(4), July-Aug. 1979, 76-87 pp.

Harkar, AN. Productivity and quality of work life, *Ambit* 8(10), Oct. 1979, 7-11 pp.

Harman, S. The transforming influence of a work quality program. *SAN Advanced Management journal*, 4(1), 1976, 4-12 pp.

Harrick, NQ & Uninn, RP The working conditions survey as a source of social indicators. *Monthly Labor Review*, 91(4), 1971, 15-24 pp.

Keaveny, Timothy J & Others Alternative to legislating the quality of work life. *Personnel Administrator* 24 (4), April 1979, 60-64 pp.

Kennedy LW & Others. Subjective evaluation of well-being-problems and prospects. *Social Indicators Research*, 5(4). 1978, 457-74 pp.

London, Manual & Others The contribution of job and leisure satisfaction to quality of life, *journal of Applied Psychology*, 62(3), June 1977, 328-334 pp.

Lupton, Tom. Efficiency and the quality of worklife the technology of reconcilliation. *Organizational Dynamics*, 4(2), Aug. 1975 68-10 pp.

Meher, MR Achieving industrial democracy through collective bargaining. *Capital*, 172(4314), May 1974, 710-712 pp.

Mills, Ted A taste of social equity. *Training and Development journal* 29, May 1975, 12-23 pp.

Mire, Joseph Improving working life the role of European unions, *Monthly Labour Review* 97(9), Sept. 1974, 3-11 pp.

Mishra, RN. Improving quality of life of a coal mine *Economic Times*, 7th Oct. 1978, 5-7 pp.

Moski, Bruno A Productivity and the quality of life. *S.R.M. Advanced Management journal*, Jul. 1973, 15-22 pp.

Mukherjee, M & Others Physical quality of life index : some international and Indian applications. *Social Indicators Research* 6(3), 1979 283-92 pp.

Nandkumar, K Indian work ethics. *Shriram Newsletter* 11(2), February 1980, 16-17 pp.

Neffa Julio Cessar. Improvement of working conditions and environment : a Peruvian experiment with new forms of work organization. *International Labour Review*, 120(4), July-Aug 1981, 473-490 pp.

Pomonias, Bobbie & Baumartel, Howard. Quality of work life movement. *Human Future*, 3(3), Autumn 1980, 246-253 pp.

Rajput, Kuldip Singh Problem of labour turnouer : a case study. *Industrial Management*, 10(7), Jul. 1971, 7-13 pp.

Rao, Mohan Monitoring human assets. *Indian Management*, 19(6), June 1980, 12-15 pp.

Rosow, Jerome M. Now is the time for productivity bargaining. *Harvard Business Review*, Jan-Feb. 1972, 79-89 pp.

Runcie John F. Dynamic ssystems and the quality of work life. *Personnel* 57(6), Nov.-Dec. 1980, 13-24 pp.

Scheips, Charles D. The humanisation of work. *Personnel*, Sept.-Oct. 1972, 38-44 pp.

Scobel, Donald N. New directions for labour-management cooperation. *Management Review*, 66(2), February 1977, 12-20 pp.

Seashore, Stanley E. Assessing the quality of working life : the US experience. *Labour & Society*, 1(2), Apr. 1976, 69-79 pp.
Seashore, Stanley E. Job satisfaction as an indicator of the quality of employment. *Social Indicators Research*, 1(2), Sept. 1974, 135-168 pp.

Shapiro, Irving S. The job ahead : enriching the quality of life in America. *Nation's Business*, June 1976, 64-68 pp.

Shin, DC, Johnson, DM. Avowed happiness as an overall assessment of the quality of life. [*Social Indicators Research* 5(4), 1978, 475-92 pp.

Shivdasani, HK. Dependence proneness in work organisation, *Indian journal of Industrial Relations*, 7(1), Jul. 1971, 53-58 pp.

Shroff, KC. My concept of quality of life : Technology should have a human face. *Industrial Times*, 21(6), April 9-22, 1979, 24-25 pp.

Singh, AD. Quality of working life : a professional approach. *Industrial Relations* 31(4), Julp-Aug. 1979, 19-26 pp.

Sinha, Prakash & Sayeed, Omer Bin Measuring quality of working life : development of an inventory. *Indian Journal of Social Work*. 41(3), October 1980, 219-226 pp.

Skrovan, Daniel J. Brief report from the ASTD Quality of work Life task force. *Training & Devalo pment Journal* 34(3), March 1980, 29 p.

Smith, Ian G. Productivity agreements and productivity : an ap - praisal and a possible approacd to productivity measurement at the plan/firm level. *Industrial Relations Journal*, 2, Winter 1971, 63-80 pp.

Smith, MP & Nock. SL. Social class and the quality of work life in public and private organisations. *Journal of Social Issues*, 36 (4), 1980, 59-95 pp.

Spink, Peter. Some comments on the quality of working life. *Journal of Occupational Psychology*, 48, (3). 1975, 179-184 pp.

Srinivas, Kalburgi M. Stress in work-life. *Manegement Government*, 12(1), April-June 1980, 70-86 pp.

Takezaqa, Shin-Ichi. The quality of working life : trends in Japan. *Labour and Society*, 1976, 29-48 pp.

Thorsrud, Einar. Work organisation and the changing role of trade unions. *Free Labour Worlds*, July-Aug. 1974, 12-15 pp.

Varadan, S S. Organisational development : the HMT way. *Lok Udyog*, (5), Aug. 1975, 19 p.

Varadan, S S. & Martyris, Bernard Towards quality of worklife. *Industrial Relations*, 29(3), May-June 1977, 109-111 pp

Venkata Ratnam C.S. Quality of working life—a case study of dock workers. *Worker Education*, September 1979, 14-20 pp.

Wacker, Gerald & Nadjer, Gerald, 7 myths about quality of working life *California Management Rewiew* 22(3), Spring 1980, 15-23 pp.

Walker, James. Flexible working hours in two British Government Offices. *Public Personnel Management*, 4, July-Aug. 1975, 216-222 p.

Walton, Richard E. *Criteris for the quality of working life*. Paper prepared for the international conference on the Quality of Working Life, Arden House, New York Aug 1972.

Walton, Richard E. Improving the quality of work life. *Harvard Business Review*, May-June 1974, 155 pp.

Walton, Richard E. Quality of working life : What is it ? *Sloan Management Review*, Fall 1973, 11-21 pp.

Walton, Richard E. Work innovations in the United States. *Harvard Business Review*, 57(4). July-August 1979, 88-98 pp.

Warman, Bruce. Improving the quality of work life. *Management Accounting*, 58(6), June 1980, 18-19 pp

Warman, Bruce. Imoroving the quality of work life. *Growth* 8(3&4), July & Oct. 1980, 30-32 pp.

Weaver, Charles N. What workers want from their jobs *Personnel*, May-June 1976, 48-54 pp.

Westley, WA. Problems and solutions in the quality of working life , *Human Relations* 1979, 32(2), 113-23 pp.

Yamaki, N. Management innovation and the quality of working life. *Productivity News* 16 (5&6), July-August 1978, 21-31 pp. A Personnel Journal Conference Report ; corporate approaches to the quality of work life. *Personnel Journal*, 1980, 59(8), 632-638 pp.

Better working lives : a symposium. *Occupational Psychology*, 47(1), 1973, 15-31 pp., 47 (2), 1973, 33-46 pp.

Personnel Management : from work to quality of worklife. *Industry Week*, 186 (8), Aug. 1975, 30-33 pp.

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LETTER FROM THE EDITOR-IN-CHIEF

With this issue readers will find 'Productivity' in a new get up. There is also a change in coverage and contents of the Journal. While 'Productivity' would continue to retain its character as a research-based Journal, it will give greater coverage to important aspects of management which have recently come into sharp focus. To make 'Productivity' a powerful vehicle of disseminating specialised knowledge on 'Productivity', we seek your valuable suggestions and comments for further improving the quality of the Journal.

In its generic sense, productivity is still interpreted in a qualitative or at best in a semi-quantitative fashion. Its dilemma has been that it has not been able to keep pace with either price increase or wage push. Doubts are also expressed that productivity drive in the rural sector has added to the volume of unemployed without absorbing this flow of population in the industrial sector.

The present economic scene and the compulsions which lie ahead in the 80s in the wake of social changes that have taken place, a new thrust has to be given to 'Productivity'. As against the better use of factors, i. e. labour, capital, management and technology, it has to recognise the behaviour pattern of human element and its linkages with aspects of environment and the quality of working life. At the enterprise level, productivity has to concern itself with changing hierarchical standards in the structures consistent with democratic aspirations and the needs of the people.

The selection of articles in this Issue is based on the recognition of this wider role which productivity can play in relation to managerial efficiency. The article on unused inventories pin-points an area where management can, with some effort, achieve substantial improvements regardless of labour productivity. Implications of this are more than financial although that in itself should be a reason enough to discover ways and means of reducing inventories. The article on marketing synergy indicates how two or more enterprises can benefit from each other's experience and strengths. In fact, barriers to productivity, can be overcome by harnessing the opportunities, which lie in every sphere of management activity. The lead article on 'Human Resource Management deals with changes and the need to look at not only individuals and groups, but also the dyad of an employee and his boss. Cliche though this may appear, improvements can come only through people.

A. N. Saxena

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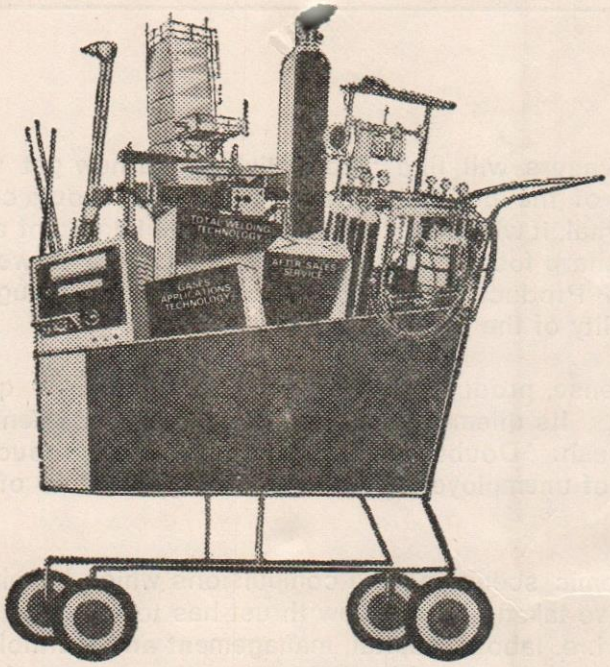

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APRIL—JUNE 1981

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Productivity
1981, XXII, 1, 3-5

Changing Concepts Of Human Resource Management

UDAI PAREEK
Indian Institute of Management, Ahmedabad

"The concept of human resource as distinct from personnel, emphasises not only on individual persons but also on groups of people functioning in an organization . . . . . Human resource management is primarily concerned with increasing enabling capability of an organization."

The personnel function is currently undergoing some drastic change. New interest has been aroused in various dimensions of personnel management resulting in some changes in the concept itself, and realisation of the importance of changing dimensions.

In the first place, the concept of human resource as distinct from personnel, emphasises not only on individual persons but also on groups of people like various teams functioning in an organisation, formal human systems like departments, inter-departmental groups and temporary systems like task groups and committees appointed for specific purposes. According to the changed concepts, human resources are available in the form of individual persons as well as in the form of collectivities of such individuals. While individuals are important resources, the various groups and teams functioning in an organisation are qualitatively different from the individual persons and deserve attention in their own right. An organisation may have excellent individuals well trained and competent in their own fields and capable of handling all kinds of problems, and yet, if the groups and teams do not function effectively the organisational effectiveness will be low. The human resources in poor teams get wasted. The focus on human resources is on both individual persons as well as groups of various sizes functioning in the organisation.

Human resource management is a proactive concept. While personnel management is primarily concerned with maintenance

functions of administering the various matters relating to the personnel in an organisation, human resource management is primarily concerned with increasing enabling capability of an organisation. The difference between the concept of personnel function and human resource system have been discussed in detail elsewhere (Pareek and Rao, 1981). Human resource management attempts to increase capability of individual persons, systems and groups, and the total organisation, to anticipate issues and problems, diagnose current problems, develop alternative ways of dealing with such problems, implement changes, prepare feedback devices to know how far action has achieved the results, and replan to increase the effectiveness further. This is mainly done through use of action research and organisation development (OD) interventions. Human resource management proceeds with and develops the basic philosophy and assumption that people are primarily motivated by changes, opportunity for development and creativity. It helps the total organisation and various groups to evolve such challenges and opportunities for individual persons as well as for various groups.

One basic change slowly coming through human resource management is the increasing concern for values. Unlike personnel management, human resource management is not "value free". In fact, no system can be value free. According to the changing concept, people, groups and the organisation should take steps to understand what values they follow and practice. Human resource management makes conscious effort to promote certain values in the organisation. One set of values relate to the development of people. The other set of values relate to the process of humanisation. Human resource management emphasises values which will slowly humanise the organisation. Such values are emphasised through OD work and action research which promote openness, exploration, collaboration and proaction. Human resource management is also concerned with humanisation of work by examining the present work processes and encouraging experiments in redesigning work so that people enjoy their work, take pride in such work, learn continuously and maximise their contribution to the organisation. According to the concept of human resource management, continuous emphasis on the process of humanisation is necessary, both, for the growth and development of the employees as well as for the development and strengthening of the organisation.

Several aspects of human resource management focus attention on development of people (Pareek and Rao, 1981) which becomes the focal point for various personnel practices to converge. For example, the role is analysed in terms of key performance areas or critical attributes or levels of responsibility in order to help people use such data, both to improve their performance and prepare plans of their development. The process of selection and placement is primarily undertaken to match the role and the person so that there is minimum wastage of human resource and the process of dehumanisation can be reduced. An integration of the person with his role is attempted in order to maximise the development of the person and his contribution. This is done through performance appraisal, potential appraisal, career development and career planning, performance feedback and counselling and training. All these devices are again focused on the development of individuals and groups. Various practices relating to the job and the role also take a new shape. Attempts are made to develop the role for the employees working in the organisation. These are reflected in practices like job rotation (to help employees to gain new experience and develop competences to undertake new responsibilities), job enrichment (to make jobs more challenging, worthwhile, and giving a sense of pride to the employees), job design and redesign (to achieve job enrichment through helping persons to develop their own systems of achieving the results and making arrangements which will maximise achievement of organisational goals and individual satisfaction and role effectiveness (through exercises which help people to cope with demands and role stresses and convert them into positive forces). Salary administration and management of Incentives and rewards are guided by the goal of developing equitability, so that employees feel that their contributions are being properly recognised and rewarded. Standardisation of various personnel practices and roles are administered with this point in view.

The traditional function of industrial relations is undergoing change and needs to be drastically redesigned. Such a function will both recognise and harness the collective power of individuals and groups in organisations. Coping with such

power should not necessarily be through conflicts and their resolution, although conflicts are a part of this sub-system and in many ways play a positive role.

There is one more trend which appears to be an important indicator of the change occuring in human resource management. Besides the emphasis on groups and teams, human resource system gives importance to the basic unit of all teams in the organisation, viz., the dyadic unit of the employee and his supervisor. All activities of human resource management should help to strengthen this two-person relationship and increase the trust and mutual understanding between the superior and the subordinate. The design of performance appraisal system, the use of performance review and feedback, and devices of self-appraisal should promote such a trust worthy and mutually reinforcing relationship. This is reflected in several new practices in these fields. To give one example, in some organisations the basic performance appraisal data are regarded as the property of the employee and his supervisor or reporting officer and these are not filed or made accessable to other levels, and, in fact, these are destroyed after three years.

In order to achieve this goal, movement in two opposite directions in human resource management is visible. On the one hand, human resource management gets diffused in the organisation, and every manager is supposed to undertake this work for his employees, and on the other, human resource management becomes a more sophisticated and specialised function. Contradictory as these two trends may seem to be, both are necessary. The responsibility of human resource development should be largely shared by all managers, and every manager should increasingly become more competent and skillful in developing his people, making his teams and groups more effective and diagnose problems in order to take appropriate action with the help of his colleagues. However, this is possible only when a more sophisticated and specialised human resource management function is developed to monitor this work, devise various ways of achieving such a goal, and continually experiment and innovate in this area. Various experiments have been made in some organisations, and it is very encouraging to see that some Indian organisations are the forerunners and Pace-setters of new practices in this area. Perhaps development of our own systems in this significant area is on the way.

REFERENCE

Pareek, Udai and Rao, T. V., *Designing and managing human resource systems.* New Delhi, Oxford and IBH, 1981.

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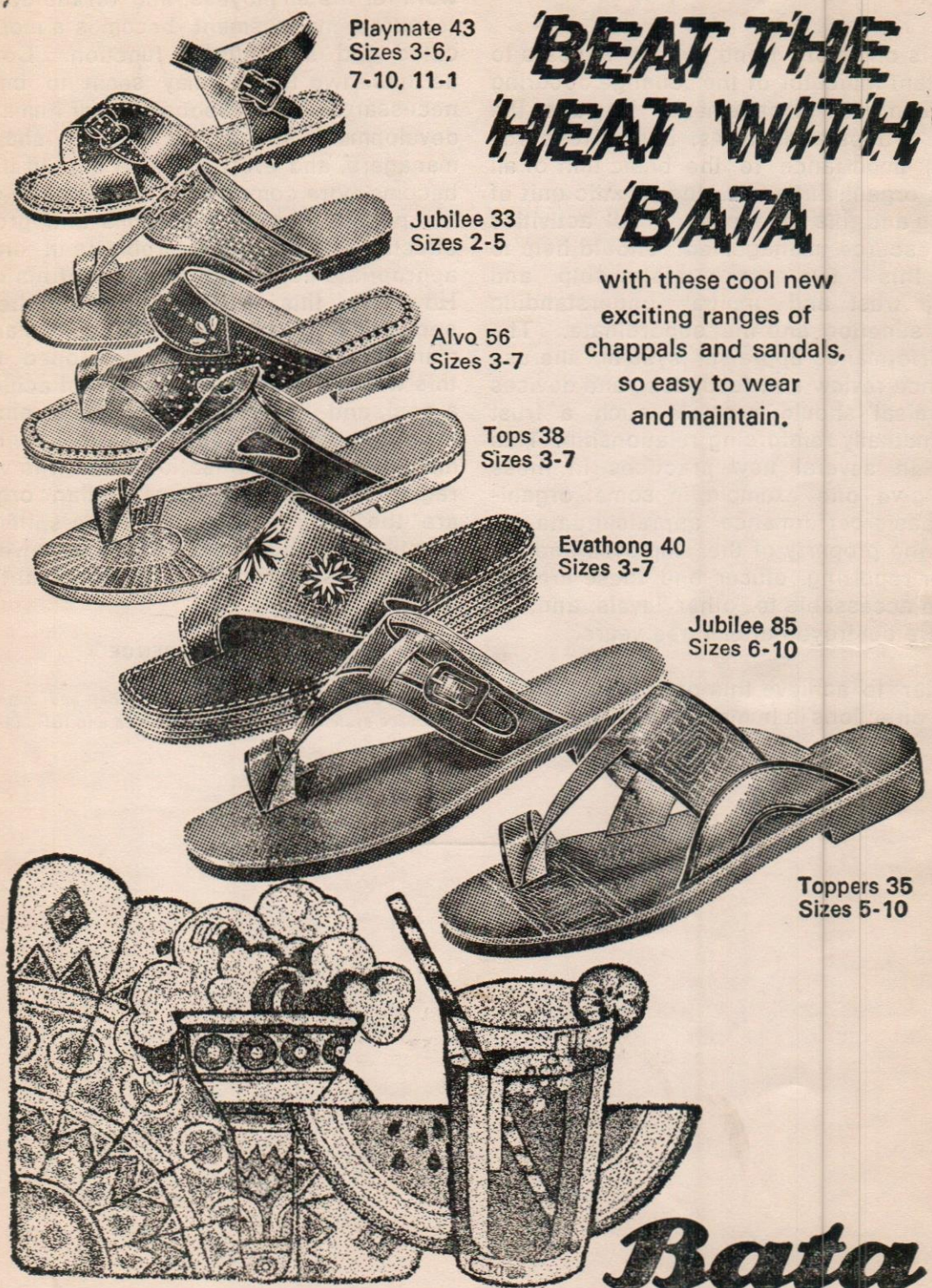

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Productivity
1981, XXII, 1, 7-12

Marketing Synergy : A Key To Increased Productivity

N. VENKATRAMAN
Management Structure and Systems Pvt. Ltd., Bombay

"Marketing Synergy can be thought of as joint preparation of programmes and plans based upon combined resources of two or more independent organisations to achieve increased individual productivity, enhanced sales and greater customer satisfaction in all spheres of activity."

Any organisation, irrespective of its size, nature of business or the style of management, when attempts an exercise on corporate planning, the availability of facilities and resources at their disposal becomes a critical factor. On account of such limiting factors, allocation of resources in some other areas cannot be carried out at the same optimal level, resulting in under-utilisation of disposable resources. This is a serious problem calling for the attention of all concerned not only at the company and industry level but also at the macro level.

As one of the aids to improve utilisation of resources and increase productivity, *Marketing Synergy* - a framework whereby two or more organisations collaborate to market a product or a service effectively is a viable alternative. This is different from the conventional sense of large scale long range mergers and from the pattern of financial or technical collaboration and emphasises only a joint marketing relationship, to enhance productivity of the participating companies. The concept assumes importance in a situation where the firms are unable to amass the required capital or know-how or the marketing expertise to venture alone in a fluid economic environment. In such situations, the consumer is left in a lurch with his needs not adequately met and, from the macro point of view, it leads to under-utilisation of scarce resources.

CONCEPT

The concept of *Marketing Synergy* can be best introduced by borrowing the analogy of symbiotic relationship from natural sciences

agents for air conditioners, refrigerators and televisions, and are showing impressive financial results.

(iii) Franchising : A classic example of franchising is that of Coca-Cola's erstwhile Indian operations where territorial rights were granted to bottlers in various regions. The main benefit is the franchiser's knowledge of local customers and the market. Further, since operations are carried out at a lower level of capital outlay, the level of risk is reduced for the parent company. Simultaneously, this practice helps to establish the brand image as can be borne out by the financial performance of Coca-Cola all over the world.

(iv) Package Tours : Jointly organised by the hotel, airline and travel agent. This could include all arrangements in respect of travel, local transport, accommodation, sight seeing, etc., the specific aspects taken care of by the respective partners of this consortium. This kind of tour offers benefits and convenience to the tourists as well as the marketing partners.

(v) Engineering Package Services : Herein, an enterprise undertakes to supply the complete system of, say, materials handling, for a project. The products need not necessarily belong to the range of one manufacturer but an understanding between producers of related products (conveyors, cranes, forklifts, etc.) can provide the services to the mutual benefit of all concerned. The detailed engineering design is carried out by the group and the products best suited to the functions are provided, thus serving as another form of turnkey eliminating avoidable competition.

(vi) Order Booking Agents : A classic case in point is the recent tie-up between ITC and Sheraton Hotels for reservations etc. This eliminated duplicating booking counters for ITC all over the world. For Sheraton, this arrangement enlarged their chain of world-wide hotels, and facilitated accommodation arrangements for their tourists travelling to India.

(vii) Joint Product Development : Offers benefits to the producers of related components in the sense that the R&D expenditure is shared. Also, the knowledge and features of the products developed concurrently aids in better marketing planning.

Quadrant III

This mode provides for two or more enterprises creating an entity which would function as a separate organisation owned by the parent companies. This is different from a merger between two companies whereby identity of one of them is lost. Licensing, formation of joint companies and associations may be classified in this quadrant.

(i) Licensing : A company can authorise another company to produce the goods by extending help in the form of necessary technology, product specifications and the brand name. This is resorted to in cases where there are major bottlenecks for expansion. Recent cases of formation of new enterprises such as Gujarat State Machinery Corporation to manufacture HMT Lathes, West Bengal Industrial Development Corporation to assemble HMT watches and Karnataka Blades under license from Wilkinson Blades of UK amply illustrate such an arrangement.

(ii) Formation of Companies : Two organisations with expertise in their respective fields, may join together to evolve a new entity. The formation of Diamines and Chemical Ltd—a creative combined project of Cellulose Products of India Ltd. Ahmedabad and The Bharat Vijay Mills Ltd. Kalol, and the case of Karnataka Explosives Ltd—a joint project of Chowgule Group and Karnataka Government are two such examples.

Similarly, individuals or diverse streams joining together to create an entity with a purpose can also be bracketed in this category. "Symbiosis", a consultancy set-up in Madras with a

highly skilled multi-disciplinary group of specialists in Engineering, Management and Computer Science, is a distinct case to illustrate this point. However, the financial or growth viability of such a system can be best illustrated by the case of Lijjat Papad, which has grown from being a Rs. 3.3 million company in 1955 to a Rs. 40 million set-up today mainly on account of co-operative marketing ventures. Khadi & Village Industries Commission (KVIC) and the recently formulated 'Good Value Marketing Company' to promote small producers of consumables are other examples.

(iii) *Marketing Efforts through 'Associations'* : Any marketing plan requires accurate data on the needs and wants of the consumers. Market Research studies are a possible source but have not been popular among small scale industrialists due to their prohibitive costs. However, a consortium approach can reduce these costs to a large extent as can be seen from the results of a recent study by Bombay Textile Research Association. This has shown an estimated cost—benefit ratio of 1 : 8.5 on account of joint research *(Economic Times Research Bureau*, Nov. 2, 1979).

Quadrant IV

This mode requires creation of a distinct entity for a short span of time. In actual practice, this mode does not exist. The relationship always begins as a short range temporary relationship and either extends to long-range temporary quadrant or to the long range permanent quadrant.

PROCEDURAL DETAILS

A relevant question which crops up is : How does the executive in the Indian industry go about operationalising this concept ? No single answer can be suited to all the situations but a general outline of procedure can serve as a starter.

Step 1 : Carry out a situation audit of the company using the principles of SWOT (Strengths-Weaknesses-Opportunities-Threats) analysis.

Step 2 : Evolve a long-range plan on the basis of the results of Step 1 to identify the situation five and ten years hence.

Step 3 : Identify the weak areas needing reinforcement to effectively exploit the opportunities and tackle the threats which were predicted in Step 2.

Step 4 : The basic areas in which a 'synergistic relationship' can be thought of can be identified at this stage, based mainly on the weak areas (typical areas for relationships are : sales organisations, physical distribution systems, product development, advertising efforts, entry into a new market, diversification and marketing expertise in research, etc.).

Step 5 : This stage consists of choosing the partner. The choice is made, keeping in mind the company's strengths and weaknesses, the exact type of relationship envisaged, the style of management and the organisational culture. Primarily, it should be construed as a marriage between two organisations with the weaknesses in one case compensated by the strengths of the other. In practice, it might not be possible to find a partner fulfilling all the requirements and a compromise may have to be made, keeping in mind an informal order of priority for the strengths envisaged.

BENEFITS

Although the advantages have been enumerated throughout the text at different points, the major benefits to the participants are summed below :

*Cost reduction through optimum utilisation of resources in

—distribution system by achieving economies of scale,

—product modification and new product development,

—advertising

*Enlarging the existing market network and exploring new areas. Consumer satisfaction

through price advantage and a reduced market search for related products.

Although difficult it may seem, it is easier to operationalise a synergic relationship than conventional mergers or an acquisition-in our context where mergers are generally disapproved because of political and social reasons.

CONCLUSION

A framework for achieving higher productivity through collaborative arrangements in realising marketing objectives of more than one company has been highlighted through examples from Indian business scene. The concept is not new, but more attention needs to be paid than hitherto has been the case, especially in the light of increased costs, competition and uncertain economic conditions. It is hoped that this will serve to initiate further thinking along these lines and eliminate avoidable duplication. □

REFERENCE

Adler, Lee Symbiotic Marketing. *Harvard Business Review*, 1966, 44(3).

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Productivity
1981, XXII, 1, 13-21

Structural Changes Of Rate Of Profits In Indian Manufacturing Industries[1]

LATA ARUN REDE
M. S. University, Baroda

"The newly established industries, through the government policies, got enough encouragement which enabled them to raise the profitability till and after 1963-64, while old industries, not only lost their earning position, but deteriorated further till 1974-75."

Economists, by and large have supported the proposition that, under perfect competition, the rate of return on investment tends towards equality in all industries. Entrepreneurs, under perfect competition, would seek to leave relatively unprofitable industries and enter profitable ones. This movement of capital is crucial to the efficiency and growth of the economy and is explained with factors like the free entry and exit of firms in industry, price-profit mechanism, the principle of factor substitution, etc. It is assumed, however, that in the beginning some differences exist in rates of profits earned by different industries (assuming further that the supply of entrepreneurs is perfectly elastic).

In view of the above, it becomes necessary to test the validity of the proposition that there is a tendency of rates of profits to converge towards a central value over time with respect to Indian Manufacturing industries. For this, the inter-industry variations in the rates of profits earned by 21 Indian Manufacturing Industries over the period 1950-51 to 1974-75, i.e., 25 years, is analysed.

Sources of Data

The study is based on the series of combined accounts (Balance Sheets, Income Statements etc.,) of different industries published by the Reserve Bank of India in its publication

1 The author is indebted to Dr. M.M. Dadi, Dept. of Economics, M.S. University, Baroda for his valuable suggestions and comments.

'Financial Statistics of Joint Stock Companies in India'. Only large and medium public limited companies are covered. Companies with paid-up capital of Rs. 0.5 million or more are classified as medium or large companies. Notwithstanding the differences in the numbers of public limited companies covered, the coverage has been kept around 80% in terms of paid-up capital of all the non-governmental, non-financial public limited companies. Only those 21 manufacturing industries are examined for which the data for the whole period 1950-51 to 1974-75 were available.

Total number of companies covered by these 21 industries increased from 419 in 1950-51 to 1068 in 1974-75. Moreover, these industries controlled around 68.5% and 34.7% of productive capital employed in the whole manufacturing sector in the years 1950-51 and 1970-71 respectively. i.e. productive capital worth Rs. 4209.9 million out of 6145.3 million in 1950-51 and Rs. 38501.2 million out of Rs. 11105.8 million in 1970-71. A considerable decline in the share of total productive capital of these industries in 1970-71 is due to considerable expansion of the manufacturing sector in addition to the industries covered in the survey industries. This is obvious from the fact that the total productive capital in the manufacturing sector as a whole has increased from Rs. 6140 million in 1950-51 to Rs. 11101 million in 1970-71. However, even in 1970-71, the share of these twenty-one industries in total productive capital still is one-third of the whole sector. Similarly, the contribution of these industries to net value added of the manufacturing sector was 61.3% in 1950-51 and 49% in 1970-71. If the share of these industries in National Income is considered, it was 3.4% in 1950-51 and 6.7% in 1970-71.

Concept

The concept of rate of profit adopted for this study is an accountant's concept. It was observed that a concept of "pure profit" as defined in Economics (Profit as reward for taking unpredictable risks) carries with it a number of problems when the question of quantification arises. This is because the net profits shown in the accounts of joint stock companies consist of interest of shareholders' funds and the reward for uncertainty bearing. This would be true provided one assumes that all other factors of production receive income from the perfectly competitive system. If this assumption is impaired in reality, which often is the case, then net profit may contain an element of monopoly revenue, gains, rent of fortuitous business ability etc. There is no tool in statistical armoury which can measure and demarcate these elements from "profit" to arrive at the abstract concept of "pure profit".

However, if interest charges on equity capital were imputed and then deducted from the 'net profits' given in the accounts, a better concept of "pure profit" could be derived. This procedure, also involves a number of practical difficulties. The first is with regard to the choice of rate of interest for imputation purposes. What rate of interest should be used to impute interest charges on equity capital ? If market rate of interest is chosen for the purpose, the problem arises of practicability of its uniform application to the equity capital of different industries. Further, a decision regarding the time period involved in borrowing (i e. equity capital is treated as borrowed funds) funds is to be made, because, interest charges differ according to time. Lastly, opportunity cost of capital also needs to be calculated. Considering the above mentioned problems and the non-availability of adequate data, it was thought desirable to take up the accountants' concept of profit rate i.e. gross rate of profit, for the study.

It is observed that two concepts of rate of profit are highly used in business for practical purposes, viz., Gross Profits as percentage of Total Capital Employed and net Profits as Percentage of Net Worth. The former represents the returns on total capital employed and thus takes into consideration the returns on both the equity and the borrowed capital, while the latter deals with the returns on the equity capital alone, thereby leaving the characteristics of borrowed capital unexplained.

The concept of gross profits includes interest charges on borrowed capital implying thereby that interest charges are not treated as cost item. This is done on the premise that if interest charges on borrowed funds are treated as cost item and therefore deducted from profits, it becomes necessary to impute the possible interest charges on equity capital and deduct these from the profits. Since imputation of interest charges on equity capital was difficult. it was felt appropriate to include the interest

charges on borrowed funds in profits assessed for the purpose.

In short, inclusion of interest charges on borrowed funds implies that one does not want to make any adjustment in total capital on account of interest as cost item. Hence, profits are taken gross of interest charges. Similarly, profits are taken gross of taxes also. The taxes are included in profits to avoid the distorting influences of differences in taxes on different industries. Moreover, profits are shown as returns on total capital employed, which means that whatever returns accrue to equity and borrowed capital are treated as profits. Hence, profits are taken gross of taxes also.

In short, profits comprise interest charges, taxes, dividends and retained earnings and are termed as gross profits. These profits are then expressed as percentage of total capital employed, where total capital is defined as net fixed assets plus current assets and is therefore equal to total net assets or total liabilities of the industry. However, both the 'profits' and 'capital' are taken as net of "depreciation charges".

Need for the Study

Having chosen the concept of gross profit rate for the study, it is intended to explore the structure of profit rates in indian manufacturing industries. Do the profit rates have a tendency to widen or narrow down over time as far as Indian Industries are concerned ?

Ideal conditions of perfect competition have never been observed in reality. Hence, perfect competition has always remained, more or less, a theoretical norm. However, it was felt that an attempt to translate this deductive reasoning into an inductive evidence can be undertaken. Postulating inter-industry differences in profit rates in the beginning of the study, it can empirically be tested, whether, over a period of time, these differences in rates of profits are wiped out or not ? If the industries earning very high profit rates in the beginning are incapable of maintaining it to the same level over time, while those with low profit rates in the beginning rise high in earning power over the same period, then a sort of equalising tendency can be inferred.

A number of studies (Bowman, 1934; Epstein. 1934; Hart, 1965 & 1968; Singh, 1968) have been undertaken to test validity of the proposition of equalising tendency of profit rates in different industries, applying statistical techniques to available empirical data.

Since independence, India has been interesting industrial transformation. Consequently, Indian industries underwent significant structural changes. With the adoption of a policy of mixed economy, the Government gave recognition to the continuation and existence of the private sector along with the public sector. Hence, economic activities left to the private sector were expected to work under more or less competitive forces, though some regulatory forces would still be in existence. The Government actively participates in core sectors and exclusively controls those sectors of the economy where individual and social interests diverge widely. The remaining sectors are left to the free forces of price-profit mechanism where the private sector can contribute relatively better in furtherance of social welfare. It is with respect to this kind of mixed environment that the study of different aspects of profitability of different Indian industries is warranted.[2]

Tables and Discussion

Table 1 below reveals the highest, lowest and mean rates of profits earned by each of the twentyone manufacturing industries over 25 years. It also gives information on the dispersion in the profit rates earned by each of these industries over the period.

It can be observed that medicines and pharmaceutical industry earned the highest rate of profit (25.2%) in 1969-70, while matches earned slightly less (23.1%) in the same year. However, the variations in profit rates on matches are relatively lesser than those for the medicines and pharmaceutical industry. Amongst the industries earning lowest profit rate, other chemical products

2 It was observed that even the exclusion of two industries viz., Iron and Steel and Cement, as the ones being exclusively under government price control, or the exclusion of seven industries, i.e. these two along with Grains and Pulses Edible Vegetable and Hydrogenated Oils Sugar Cotton Textiles and Paper and Paper Products (as thsse industries also experienced some price control over some years), cause no variations in the trends, observed as far as inter-industry variations in profit rates are concerned.

Table 1

Industry Inter-Variations in Rates of Profit : Highest, Lowest and Mean Profit Rates, Coefficient of Variation and Number of Years of Losses

Industry	Rate of Profit			C.V.	No. of Years of Losses
	Highest	Lowest	Mean		
1. Grains and Pulses	21.7 (1964-65)	4.0 (1972-73)	12.6	.437	Nil
2. Edible Vegetables and Hydrogenated Oils	16.2 (1973-74)	-1.8 (1954-55)	7.5	.667	1 (1954-55)
3. Sugar	15.7 (1972-73)	4.9 (1970-71)	8.9	.258	Nil
4. Tobacco	18.4 (1965-66)	7.9 (1953-54)	13.1	.198	Nil
5. Cotton Textile	15.1 (1973-74)	2.9 (1957-58)	7.9	.367	Nil
6. Silk-Rayon and Woollen Textiles	21.5 (1974-75)	1.7 (1952-53)	12.1	.496	Nil
7. Medicines and Pharmaceutical Preparations	25.2 (1969-70)	4.7 (1953-54)	14.4	.472	Nil
8. Matches*	23.1 (1969-70)	8.0 (1957-58)	14.4	.236	Nil
9. Pottery, China Earthenware and Structural Clay Products	16.5 (1972-73)	6.5 (1968-69)	9.5	.268	Nil
10. Paper and Paper Products	22.4 (1974-75)	5.8 (1967-68)	10.0	.340	Nil
CONSUMERS' GOODS SECTOR	14.7 (1973-74)	5.1 (1952-53)	9.7	.263	Nil
11. Iron and Steel	15.7 (1955-56)	1.9 (1972-73)	9.0	.411	Nil
12. Aluminium	16.9 (1964-65)	1.6 (1953-54)	9.3	.433	Nil
13. Basic Industrial Chemicals	18.4 (1974-75)	2.5 (1953-54)	9.3	.433	Nil
14. Cement	14.1 (1966-67)	2.8 (1973-74)	9.4	.298	Nil
BASIC GOODS SECTOR	13.5 (1955-56)	6.2 (1958-59)	10.0	.200	Nil
15. Transport Equipment	11.4 (1965-66)	1.4 (1953-54)	7.7	.390	Nil
16. Electrical Machinery Apparatus and Appliances	15.9 (1963-64)	6.1 (1953-54)	11.3	.381	Nil
17. Machinery (Other than Transport Equipment)	12.2 (1963-64)	5.7 (1953-54)	8.9	.213	Nil
18. Ferrous/Non-Ferrous Metal Products	16.8 (1958-59)	-3.2 (1952-53)	9.3	.559	1 (1952-53)
CAPITAL GOODS SECTOR	12.8 (1964-65)	4.8 (1953-54)	9.4	.223	Nil
19. Jute Textiles	16.5 (1962-63)	-0.6 (1956-57)	6.1	.656	1 (1956-57)
20. Other Chemical Products	17.9 (1974-75)	-6.2 (1952-53)	10.0	.590	2 (1952-53 & 1954-55)
21. Rubber and Rubber Products	17.2 (1968-69)	10.0 (1962-63)	12.6	.159	Nil
INTERMEDIATE GOODS SECTOR	14.8 (1962-63)	1.5 (1956-57)	8.9	.315	Nil
WHOLE MANUFACTURING SECTOR	14.2 (1974-75)	6.3 (1957-58)	9.5	.200	Nil

Source : Financial Statistics of Joint Stock Companies in India in 3 Vols, 1967, 1975, 1977, Reserve Bank of India.
Note : *Data on Match Industry are available upto 1969-70 only.

incurred the maximum losses (—6.2%) and relatively highly fluctuating profit rates over the period of twenty five year (coefficient of variation=590). Another important feature which is noticable is that majority of the modern industries that earned lowest rates of profit during the early fifties, earned highest profit rates in early seventies, viz., edible vegetable and hydrogenated oils, silk-rayon and woollen textiles, medicines and pharmaceutical preparations (consumer goods sector); aluminium, basic industrial chemicals (basic goods sector), transport equipment, electrical machinery, apparatus and appliances, machinery (other than transport equipment), ferrous/nonferrous metal products (capital goods sector), other chemical products (intermediary goods sector). This implies that these modern industries, majority of which belong to basic and capital goods sector, though suffered from low profitability in their initial stages, were capable of earning high rates of profit toward the end of the study period.

Industries like grains and pulses, sugar, pottery, china, earthenware and structural clay products, paper and paper products (consumers sector), iron and steel and cement (basic goods sector), and rubber and rubber products on the other hand earned lowest rates of profit in late sixties early seventies. These are mainly the traditional industries which enjoyed better profitability in the early fifties.

The rubber and rubber products industry, had the lowest fluctuations in profitability ratios (C. V.=.159) and also earned, on an average, relatively high rate of profit i.e , mean profit rate, over the study period. Similarly, edible vegetable hydrogenated oils industry had the largest fluctuations in profit rate (C.V.=.667) and also earned, on an average, a very low rate of profit (7.5% mean profit rate).

From Table 2, it is observed that industries like matches and grains and pulses enjoyed the most superior earning positions till early sixties, while medicines and pharmaceutical preparations dominated the period from mid-sixties onwards till the end of the study period. Similarly, industries like edible vegetable and hydrogenated oils, cotton textiles, pottery china earthenware and structural clay products, cement, transport equipment and jute textiles suffered from low rates of profits till mid-sixties while it was mainly the jute textiles industry which earned lowest rate of profit during the more number of year after mid sixties.

Have the inter-industry profit rates a tendency to narrow down or have they widened over the study period ? An answer to this question is sought through working out the coefficient of variation of profit rates at inter-industry level for each of the twenty-five years, and are presented in column four of Table 2. In order to further strengthen the conclusions, rank correlation coefficient between profit rates of different industries in 1950-51 and each of the following years, are worked out presented in last column.

Trend in the value of coefficient of variation examined along the rank correlation coefficient between rates of profits, enables to explore the existence or absence of equalising tendency. A fall in the value of coefficient of variation over time is indicative of narrowing down of inter-industry dispersion of profit rates while a rising value of coefficient of variation implies widening of dispersion of inter-industry profit rates. Briefly speaking, a declining trend in coefficient of variation implies a tendency of profit rates to converge towards a central value through narrowing the profitability gap between different industries and *vice-versa.*

It is obvious from Table 2 that dispersion in profit rates in manufacturing industries widened during 1950-51 to 1952-53 because the value of coefficient of variation increased over these three years. However, there is clearly a tendency for profit rates to narrow down the period 1952-53 to 1963-64, which is obvious from a continuously declining value of coefficient of variation over these eleven years (C.V. declined from .871 in 1952-53 to .179 in 1963-64). After 1963-64 the dispersion in profit rates has remained more or less fluctuating. Even then, it is obvious from the values of coefficient of variation that there is a tendency towards widening of profitability gap of different industries over the period 1963-64 onwards till 1974-75. This is obvious from the fact that the coefficient of variation having once reached its minimum value (.179) in 1963-64 has not only risen in value in the years following 1963-64, but has remained above its minimum value over the remaining years. Hence, even though there are fluctuations in the C.V. value

Table 2

Inter-Industry Variations in Rates of Profits Highest, Lowest Profit Rates, Rank Correlation Coefficient and Number of Industries having Losses.

Years	Rate of Profit			C.V.	No. of Inds. with Losses	Rank Corr. Coeff. in relation to 1950-51 profit rates
	Highest	Lowest	Range			
1	2	3	4	5	6	7
1950-51	14.8 Matches	1.8 Transport Equipment	13.0	.466	Nil	—
1951-52	15.0 Rubber and Rubber Products	0.6 Edible Vegetable and Hydro-genated Oils	14.4	.524	Nil	.910
1952-53	13.9 Matches	-6.2 Other Chemical Products	20.1	.871	Two 1. Cement 2. Other Chemical Products	.897
1953-54	13.8 Grains and Pulses	0.5 Cement	13.3	.642	Nil	.903
1954-55	16.9 Grains and Pulses	-1.8 Edible Vegetable and Hydrogenated Oils	18.7	.613	Two 1. Edible Vegetable and Hydrogenated Oils 2. Other Chemical Products	.909
1955-56	18.6 Grains and Pluses	2.4 Jute Textiles	16.2	.489	Nil	.406
1956-57	19.2 Grains and Pulses	-0.6 Jute Textiles	19.8	.488	1 Jute Textiles	.620
1957-58	17.8 Grains and Pulses	2.3 Edible Vegetable and Hydroge-nated Oils	15.5	.481	Nil	.489
1958-59	17.4 Grains and Pulses	4.2 Cotton Textiles	13.2	.354	Nil	.368
1959-60	19.8 Grains and Pulses	7.3 Cement	12.5	.296	Nil	.132
1960-61	19.6 Grains and Pulses	7.21 Pottery China Earthen-ware and Structural Clay 2. Iron and Steel	12.4	.293	Nil	-.094
1961-62	16.6 Matches	3.4 Jute Textiles	13.3	.259	Nil	.069
1962-63	19.6 Matches	7.1 1. Edible Veg. and Hydro-genated Oils 2. Sugar	2.5	.287	Nil	.132

1	2	3	4	5	6	7
1963-64	16.9 Matches	6.5 Edible Veg. and Hydrogenated Oils	10.4	.179	Nil	.048
1964-65	21.7 Grains and Pulses	5.4 Jute Textiles	16.3	.328	Nil	-.012
1965-66	23.3 Medicines and Pharmaceutical Preparations	5.4 Cotton Textiles	17.9	.347	Nil	-.153
1966-67	23.3 Medicines and Pharmaceutical Preparations	2.3 Jute Textiles	21.0	.658	Nil	-.094
1967-68	20.6 Medicines and Pharmaceutical Preparations	1.3 Jute Textiles	19.3	.475	Nil	-.076
1968-69	22.0 Medicines and Pharmaceutical Preparations	3.6 Jute Textiles	18.4	.471	Nil	-.123
1969-70	25.2 Medicines and Pharmaceutical Preparations	3.0 Jute Textiles	22.2	.487	Nil	-.077
1970-71*	21.1 Medicines and Pharmaceutical Preparations	4.9 Sugar	16.2	.374	Nil	-.140
1971-72*	20.5 Medicines Pharmaceutical and Preparations	3.4 Edible Vegetable and Hydrogenated Oils	17.1	.350	Nil	-.100
1972-73*	20.0 Medicines and Pharmaceutical Preparations	1.9 Transport Equipment	18.1	.434	Nil	-.348
1973-74*	18.9 Medicines and Pharmaceutical Preparations	0.8 Jute Textiles	18.1	.464	Nil	-.507
1974-75*	22.4 Papar and Paper Products	2.4 Aluminium	20.0	.424	Nil	-.329

Source : Financial Statistics of Joint Stock Companies in India, 3 Vols., 1967, 1975, 1977, Reserve Bank of India.
Note : *The number of Industries covered is 20 as data on "Matches" are not available for these years.

in latter period, its higher values are indicative of widening of the profitability gap.

Further analysis of the C.V. data indicates that it has a parabolic trend, rising over the years 1952-53 to 1963-64, reaching its minimum value in 1963-64, and rising and remaining above its minimum value (though fluctuating) till 1974-75. It implies that there was a widening of profitability gap till 1952-53 followed by a narrowing down of the profitability gap over the period 1952-53 to 1963-64, thereby indicating a tendency of profit rates to converge towards a central value or indicating the levelling effects in profit rates earned by different industries over this period of eleven years, and widening of profitability gap again from 1963-64 onwards till the end of the period.

From the above analysis, one can infer that for the period 1952-53 to 1963-64, there are some levelling effects as there is a definite declining trend in the value of coefficient of variation. However, the unchanged values of coefficient of variation at the beginning and at the end of the period indicate that the dispersion in the profit rates has remained almost same at the two ends.

As far as structural changes are concerned, it would not be enough to examine the trends in the value of coefficient of variation alone and it will have to be supplemented with the rank correlation data. This will show whether the industries were capable of maintaining their earning positions over time or not. The equalising tendency or the levelling effect in profit rates may be the result of wiping out or decline in the abnormal profits earned by some industries and rise in profitability of industries earning low profit rates in 1950-51. Competition among firms and entry of new firms within the industry creates such a situation.

The Rank Correlation Coefficient between the profit rates when worked out, indicates whether industries ranking top in profitability in 1950-51, could continue to top in following years or not, or, industries ranked in the lowest ladder of profitability in 1950-51 remained at the same position during the following period.

The rank correlation coefficients were estimated by arraying the industries in descending order of their profit rates and by ranking them in ascending order. These ranks of 1950-51 were then correlated to the ranks of each of the following years.

A changing value of rank correlation coefficient indicates changing earning positions and negative values of this coefficient imply reversing of the ranks and the earnings positions of industries. Keeping in mind these implications following conclusions are drawn from the values of rank correlation coefficient presented in the last column of Table 2.

It reveals that the majority of the Indian manufacturing industries maintained their earning superiority in the initial period of study, i.e., till 1954-55 (value of Rank Correlation Coefficient is very high). However, from 1955-56 onwards, not only has there been a decline in the value of this coefficient, but it reached very low level in 1963-64 (.048) and become negative from 1964-65 onwards. This is an indication of changing profitability ranks of these industries and implies that industries experienced great changes in their earning position.

Further, the rank correlation coefficient is observed to have assumed negative values from 1964-65 onwards (though quite low in the beginning, but, relatively high from 1972-73 onwards), indicating thereby, that, not only the highly profitable industries of 1950-51 e.g. grains and pulses, sugar, paper and paper products, iron and steel, cement, etc. have lost their earning superiority over this period, but the industries earning low profitability in 1950-51 e.g. chemical and engineering industries have raised their earnings very high and acquired superiority in earnings in latter period.

If the trends in rank correlation coefficient are examined alongwith the trends in the coefficient of variation, a very interesting conclusion can be drawn. It has already been observed earlier that the coefficient of variation denotes a parabolic trend in variations in inter-industry profit rates. It is further observed that till 1952-53, the C. V. has increased indicating

3 Industries like silk-rayon and woollen textiles medicines and pharmaceutical preparations aluminium basic industrial chemicals, transport equipment electrical machinery apparatus and appliances ferrous/non-ferrous metal products other chemical products etc.

widening of dispersion of profit rates while rank correlation coefficient has remained quite high till 1951-55, indicating thereby that earning positions were maintained by different industries over this period and that there was a wide gap in profit rates earned by different industries. However, from 1953-54 onwards not only has C. V. fallen continuously in value till 1963-64, but even the rank correlation coefficient has also declined in value and reached its lowest positive value (.048) in 1963-64. These trends imply that the profitability gap started narrowing down and at the same time the earnings positions (ranks by profit rates) of different industries also underwent big changes, i.e., industries earning low profits in the begining started earning high profits while those earning high profits in the beginning became low profitability industries over this period. This is a clear indication of narrowing down of the gap between profit rates earned by different industries over this period. Hence, it implies that Indian manufacturing industries experienced an equalising tendency in profit rates over the period 1953-54 to 1963-64 i.e. 11 years.

However, after 1963-64 not only has there been a rise in the value of C.V., indicating widening of the profitability gap between those industries, but, the rank correlation coefficient has assumed negative values, which are quite high towards the end of the period under study. Moreover, in 1974-75, the C.V. assumes, though slightly less, almost its equivalent value of 1950-51, indicating thereby that the dispersion in profit rates has widened and has come back to its original state. However, a negative and high value of the rank correlation coefficient emphasises the fact that though dispersion is almost similar to that of 1950-51, there have been drastic changes in the earnings positions of these industries in these two periods. Industries earning high profits in 1950-51 e.g. grains and pulses iron and steel cement etc. have become low earning industries in 1974-75 while those earning low profits in 1950-51 e.g. chemical and engineering industries have become highly profitable ones in 1974-75. This is highly indicative of a change in structure of profit rates of these industries over the 25 years though dispersion at the two ends of the period has remained same.

Having concluded thus, it becomes necessary to pinpoint those industries in the study which have been responsible for this tendency. As far as the equalising tendency observed over the period 1953-54 to 1963-64 is concerned, it has been the result of the combined effect of decline in the profitability of old industries like jute textiles, iron & steel and cement etc., and a rise in the profitability of industries like medicines & pharmaceutical preparations, silk-rayon & woolen textiles, chemical & engineering industries etc. When this levelling effect is examined in the light of government policy, we observe that the basic and heavy industries which have been strongly encouraged by the government through its five year plans and Industrial Policy Resolution of 1956 have been capable of raising their profit rates quite high over the period. On the other hand, the old and traditionai industries like grains & pulses, cotton textiles, jute textiles, iron & steel, cement, etc., either had decline in profitability over the period or negligible rise, due to considerable government control on their prices, production or distribution.

In short, the newly established industries, through the government policies, got enough encouragement which enabled them to raise their profitability till and after 1963-64, while old industries, not only lost their earning positions, but deteriorated further till 1974-75. Hence, the profitability differences which narrowed down over the period 1953-54, till 1963-64, widened thereafter. This implies that modern industries (particularly the chemical & engineering industries) experienced rise in their earnings at a rate faster than the old industries.

REFERENCES

(i) Epstein P.C. : *Industrial Profits in United States.* National Bureau of Economic Research, New York, 1934.

(ii) Singh, A. & Whittington, *G. Growth, Profitability and Valuation, A Study of United Kingdom Quoted Companies.* Cambridge University Press Cambridge, 1968.

(iii) Bowman, R. T. : *Statistical Study of Profits.* Philadelphia, 1934,

(iv) Hart, P. E : *Studies in Profit, Business Saving and Investment in United Kingdom, 1920-62.* Vol. I-II. George Allen & Unwin, London 1965 and 1968.

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Unused Inventories In Central Government Heavy Engineering Enterprises

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Experience has shown that a reduction of about 20-25 percent of stock is within easy reach of management through modern inventory control techniques. About 157 to 196 crores of capital can be realised for active use apart from saving 10-15 percent of annual carrying cost of stocks in the public sector heavy engineering undertakings alone.

Ten enterprises of the Central Government as on 31st March 1978 were engaged in the manufacture of capital goods required by major industries and power generation complexes. The names of these ten enterprises and the year of incorporation are indicated below :

Sl. No.	Name of the Enterprise	Year of Incorporation (Registration)
1.	Jessop & Co. Ltd. (became a Govt. Co. w.e.f. 1.4.1973)	1788
2.	Bridge & Roof Co. (India) Ltd. (became a Govt. Co. w.e.f. 29.7.72; subsidiary of Balmer Lawrie & Co. Ltd.)	1920
3.	Heavy Engineering Corporation Ltd.	1958
4.	Tungabhadra Steel Products Ltd., (became a Govt. Co. since 1967)	1960
5.	Bharat Heavy Electricals Ltd.,	1964
6.	Mining & Allied Machinery Corpn. Ltd.	1965
7.	Triveni Structurals Ltd.,	1965
8.	Bharat Heavy Plate & Vessels Ltd.,	1966
9.	Braithwate & Co. (India) Ltd.,	1976*
10.	Burn Standard Co. Ltd.,	1976*

* Year of becoming Government Company.

These heavy engineering undertakings have grown in number as well as in size both through merger and expansion during 1966-78. In 1966-67 there were only four enterpises under production nos. 3, 4 & 5 and Heavy Electricals (India) Ltd., which was later merged with BHEL. These had capital employed of Rs. 170.52 crores and sales turnover of Rs. 15.06 crores in 1966-67. In 1977-78, the capital employed increased by 354.6 percent to Rs. 775.26 crores and turnover increased to Rs. 719.40 crores, i.e., by about 48 times. The total equity and loan investment in these 10 enterprises was of the order of Rs. 827.01 crores on 31st March 1978. Thus, currently out of every 11.9 rupees invested in all the goods producing enterprises one is in those belonging to heavy engineering. These enterprises contributed 11 percent of the total gross profit earned during 1977-78 and were responsible for 47 percent of net loss of Rs. 92.55 crores incurred by all the goods producing enterprises.

Level of Inventories

The inventories as a percentage of total value of produce fell from 225 (1966-67) to 116 (1977-78). The average inventories in absolute terms increased from Rs. 62 crores to Rs. 714 crores over the period under study. The cost of sales during the period increased from Rs. 28 crores to Rs. 460 crores as shown in Table 1. These figures are graphically presented in Fig. 1 for identifying the changing pattern of inventories and cost of sales.

It is one of the few cases when holding of inventories in all the twelve years have been more than the cost of sales. That is why the cost of sales curve passes through the bars representing average inventories in all the years under study in Fig. 1. In the initial years this group of enterprises carried excess inventories as revealed by some of the case studies mainly due to the facts that (i) the plants had planned for a high production level which could not be achieved; (ii) the production was job-based that necessitated stocking of different items; and (iii) procurement of material against work order had been usually made in one lot. In subsequent years some improvement is seen in management of inventories if judged from the stock turnover rate. Inventory-turnover ratio is the ratio of annual usage or cost of sales to average inventory during the period. It gives a quick appraisal of inventory condition

Table 1

Year	Rs. in crores		Inventories as % of cost of sales	Inventories in terms of months of cost of sales (nos.)	Inventories turnover rate 2÷3
	Cost of sales	Value of average inventories			
1	2	3	4	5	6
1966-67	27.77	62.41	224.74	27.0	.44
1967-68	38.82	89.87	231.56	27.8	.43
1968-69	71.85	124.55	173 35	20.8	.58
1969-70	91.89	151.71	165.10	19.8	.61
1970-71	99.64	177.77	178.41	21 4	.56
1971-72	110.16	215 53	195.65	23.5	.51
1972-73	193.20	286.89	148.49	17.8	.67
1973-74	210.44	372.71	177.11	21.3	.56
1974-75	319.88	529.32	165.47	19 9	.60
1975-76	459 22	715.25	155.72	18.6	.64
1976-77	601.29	775.29	128.93	15.5	.78
1977-78	676.30	784 80	116.04	13.9	.86

and reflects not only proportional investment but how well the stocks are moving. It is a quick guide to the 'mileage' obtained from the money tied up in stocks. During the period under study the inventory turnover rate had gradually increased from 0.44 in 1966-67 to 0.86 in 1977-78. The inventory holdings in terms of months of produce has been reduced from 27.8 in 1967-68 to 13.9 in 1977-78.

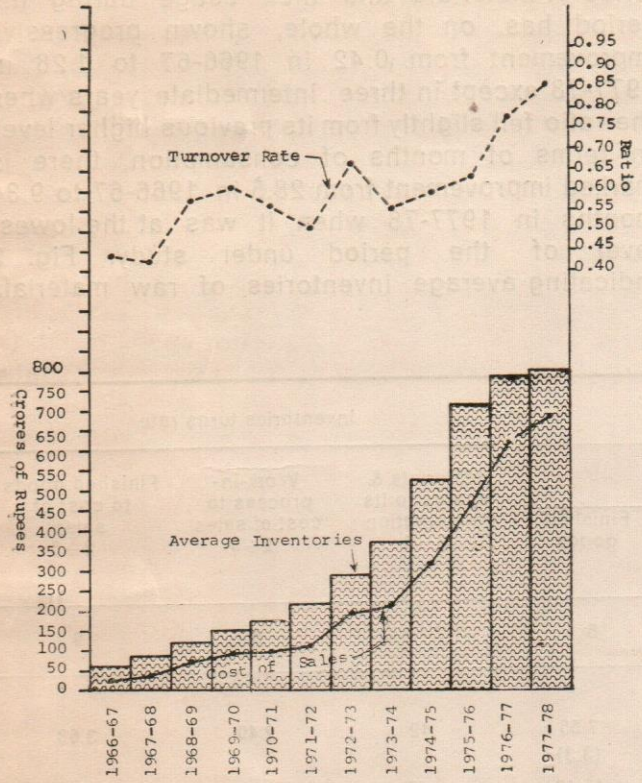


Fig. 1. Inventory Chartwatch—Heavy Engineering

The facts collected by the Committee on Inventories Control of Bureau of Public Enterprises, Government of India (Reference made to Report No. 2 on Heavy Engineering Corporation-Heavy Machine Building Unit) show that the inventory-turnover ratio in foreign countries in heavy engineering is about 2.75 whereas in this group of enterprises the corresponding ratio during the period had never been more than one. In USA, the ratio of net sales to inventory for 327 corporations in the group of industrial machinery shows a range of 7.8 to 3.4 upper and lower quartile, the median being 4.9 (Hayel, pp. 228-29.) The comparison of turns ratios with American or other foreign companies may not be helpful in determining the quantum of under-utilisation of capital invested in inventories due to working and environmental differences, but it does indicate that all is not well with the management of inventories in this group.

A further comparison of heavy engineering inventory of public sector undertakings with that of private sector companies in India also does not indicate encouraging position. The comparable data of 29 private sector joint stock companies with paid-up capital of Rs. 1 crore and above and engaged in the manufacture of all electrical, machinery and apparatus and appliances are reproduced in Table 2. It may be seen that against the private sector inventory holding of

Table 2

Year	Rs. in crores		In months	Turns Rate 2÷3
	Cost of sales	Value of average Inventories	Inventories in terms of months of sales	
1	2	3	4	5
1971-72	325.73	113.51	4.18	2.87
1972-73	368.23	122.11	3 98	3.02
1973-74	416.31	137.33	3.96	3.03
1974-75	599.58	167.81	3.36	3.57
1975-76	566.93	190.40	4.03	2.98

about 4 months, public sector enterprises had an inventory level which varied between 17.8 to 23.5 months of cost of sales during the above five years. The turns rate of the 10 undertakings of public sector in 1971-72 to 1975-76 ranging between 0.51 to 0.67 was very low as compared to that of those in private sector being between 2.87 to 3.57. This shows that inventories in private sector, if judged from turns ratio, are on the whole better managed than in the public sector in industrial group of heavy engineering.

Inventory Components

The data on heavy engineering inventories according to different components, viz., crude material and spares, work-in-process and finished goods; consumption of materials and cost of sales; and their appropriate ratios are summarised in Table 3.

Raw Materials : The turnover ratio of inventories of materials and their usage during the period has, on the whole, shown progressive improvement from 0.42 in 1966-67 to 1.28 in 1977-78 except in three intermediate years when the ratio fell slightly from its previous higher level. In terms of months of consumption, there is marked improvement from 28.5 in 1966-67 to 9.34 months in 1977-78 when it was at the lowest level of the period under study. Fig. 2 indicating average inventories of raw materials

Table 3

Year	Rs. in crores					Inventories turns rate		
	Cost of Sales	Value of materials & spares consumed	Av. Inventories: Raw materials & spares	Av. Inventories: Work-in-process	Av. Inventories: Finished goods	Materials & spares to its consumption 3÷4	Work-in-process to cost of sales 2÷5	Finished goods to cost of sales 2÷6
1	2	3	4	5	6	7	8	9
1966-67	27.77	18.08	42.99 (28.5)	11.87 (5.13)	7.55 (3.3)	.42	2.40	3.68
1967-68	38.82	25.27	52.84 (25.1)	21.63 (6.7)	15.40 (4.8)	.48	1.79	2.52
1968-69	71.85	38.21	66.41 (20.9)	37.59 (6.3)	20.47 (3.4)	.57	1.91	3.51
1969-70	91.89	55.43	75.21 (16.3)	51.50 (6.7)	25.00 (3.3)	.74	1.78	3.67
1970-71	99.64	80.32	84.72 (12 6)	48.45 (5 8)	44.60 (5.4)	.95	2.06	2.23
1971-72	110.16	83.25	96.88 (14.0)	59.49 (6.5)	59.16 (6.4)	.86	1.85	1.86
1972-73	193.20	117.77	127.51 (13.0)	100.34 (6.2)	59.04 (3.7)	.92	1.92	3.27
1973-74	210.44	188.20	163.59 (10.4)	162.25 (8.1)	66.87 (3.8)	1.15	1.48	3.15
1974-75	319.88	235.27	234.75 (12.0)	157.85 (5.9)	136.72 (5.1)	1.00	2.03	2.34
1975-76	459.22	361.48	307.03 (10.2)	176.88 (4.6)	231.34 (6.0)	1.18	2.60	1.99
1976-77	601.29	386.17	313 38 (9.74)	201.86 (4.03)	260.05 (5.19)	1.23	2.98	2.31
1977-78	676.30	405.45	315.55 (9.34)	216 96 (3.83)	253.29 (4.49)	1.28	3.13	2.67

NOTE : Figures in parentheses relate to inventories in terms of months of consumption of materials and spares for crude materials; and of cost of sales for work-in-process and finished goods.

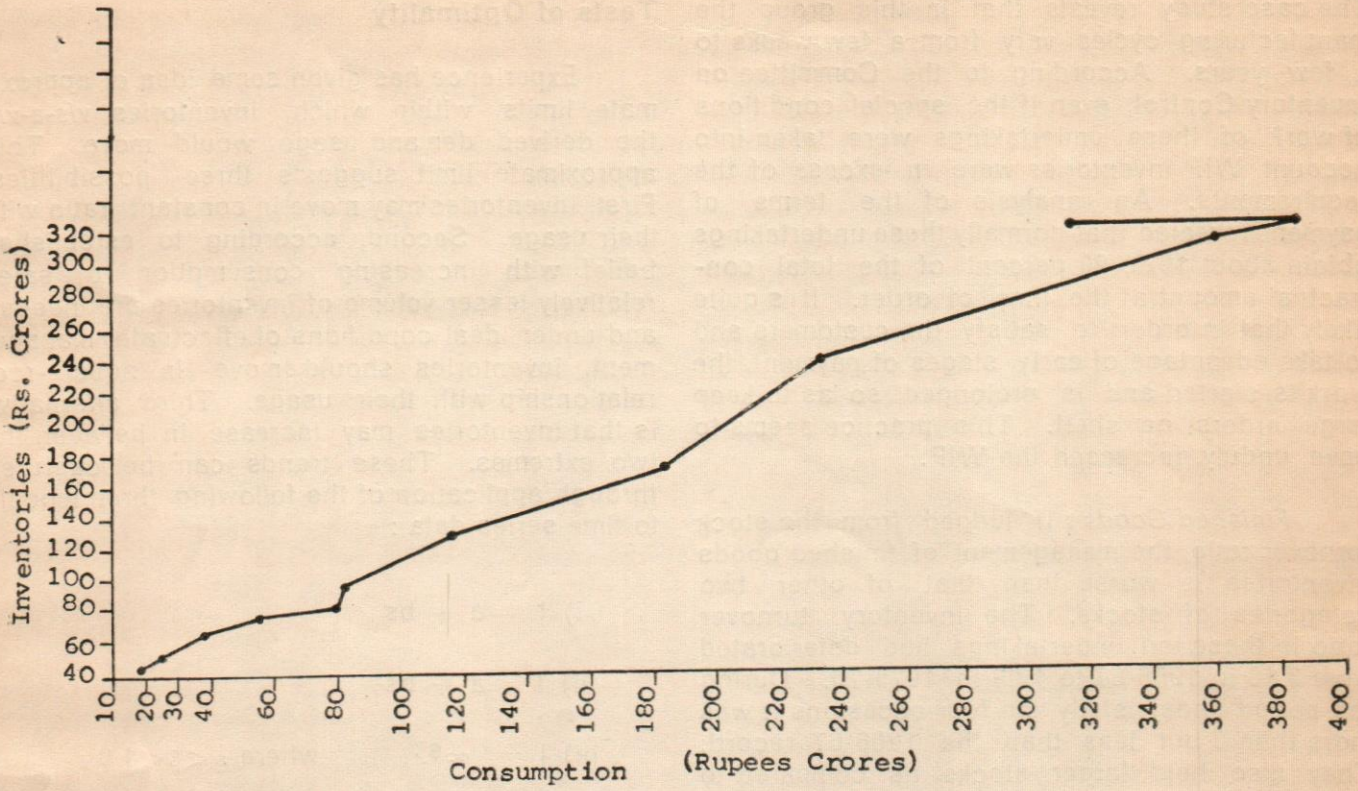


Fig. 2 Inventories of Raw Materials and Their Consumption Relationship—Heavy Engineering

and spares and their consumption, shows somewhat concave formation. This gives further evidence of economies of scale. In 29 large sized joint stock companies of private sector during 1971-72 to 1975-76 the material consumption and their average inventories ratio varied between 4.02 to 4.2, whereas in public sector enterprises the said ratio fell in the range of 0.86 to 1.18. This indicates the extent of under-utilisation of the investment in crude material.

Work-in Process : In this category, the turns ratio over the period has not shown any notable improvement in the first nine years. In 1966-67 it was 2.48 and this figure did not exceed in any of the nine years. Subsequently, it increased gradually from 2.6 to 2.98 and then to 3.13 in the last year of the study. In the said 29 companies of private sector, the ratio of cost of sales and average value of work-in-process inventories ranged between 16.22 to 21.52 over the period 1971-72 to 1975-76. The corresponding ratio in public sector enterprises during the period varied between 1.48 to 2.03. This shows how relatively inactive the capital is in public sector enterprises. Fig. 3 shows the rising trend in inventories of WIP over the period under study.

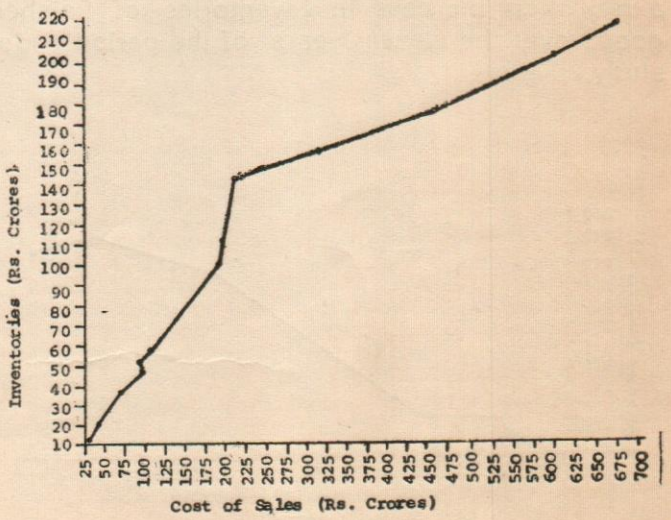


Fig. 3 Inventories of Work-in-Process and Cost of Sales Relationship—Heavy Engineering

The case study reveals that in this group the manufacturing cycles vary from a few weeks to a few years. According to the Committee on Inventory Control, even if the special conditions of work of these undertakings were taken into account, WIP inventories were in excess of the requirements. An analysis of the terms of payment revealed that normally these undertakings obtain about 10 to 20 percent of the total contractual amount at the time of order. It is quite likely that in order to satisfy the customers and to take advantage of early stages of payment, the work is started and is prolonged so as to keep large orders on shelf. This practice seems to have, unduly, increased the WIP.

Finished Goods : If judged from the stock turnover ratio, the management of finished goods inventories is worse than that of other two categories of stocks. The inventory turnover ratio in these ten undertakings had deteriorated from 3.68 in 1966-67 to 1.99 in 1975-76. During the period under study, on four occasions it was more than 3 but less than the 1966-67 record. They also held larger stocks as compared to their counterparts in private sector. The said large sized 29 private sector joint stock companies carried during 1971-72 to 1975-76 inventories of finished goods equal to 1.23 to 1.36 months of cost of sales. The ten enterprises in similar industrial groups of public sector had stocks of finished goods equal to 3.7 to 6.4 months of the cost of sales in the said period. Fig. 4 shows a very sharp increase in inventories of finished goods over the eleven years of the period under study.

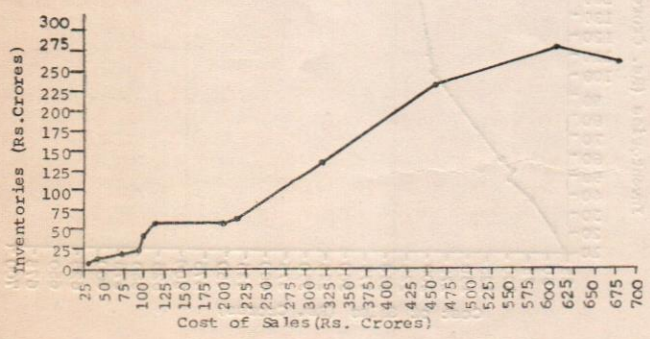


Fig. 4 Inventories of Finished Goods & Cost of Sales Relationship—Heavy Engineering

Tests of Optimality

Experience has given some idea of approximate limits, within which, inventories *vis-a-vis* the derived demand/usage would move. This approximate limit suggests three possibilities. First, inventories may move in constant ratio with their usage. Second, according to established belief with increasing consumption or sales relatively lesser volume of inventories are needed and under ideal conditions of effectuate management, inventories should move in square-root relationship with their usage. Third alternative is that inventories may increase in between the two extremes. These trends can be captured through application of the following three models to time series data :

i) $I = a + bs$

ii) $I = a + bs^{\frac{1}{2}}$

iii) $I = \propto s^{\beta}$ where $\frac{1}{2} < \beta < 1.0$

Here I stands for inventories, a-safety stocks, b/α-policy variable and S for sales/usage. The value of the exponent will indicate the degree of economies of scale in the holding of inventories. A general form equation $I = a + bs^{\beta}$ could give better idea about the extent of economies of scale, but unfortunately, there are statistical difficulties in establishing by linear regressions an equation of the general form and as such this model cannot be applied. The applications of three models will give insight in the inventory behaviour, and assess the extent to which there had been economies of scale in inventory holding. In model (i), inventories form a constant ratio with usage. In model (ii), stocks are in square-root relationship to derived demand. The model (iii) , holds the assumption that economies of scale exist, but are not as great as those indicated by the square-root relationship.

Application of Models

Model I : The inventories of raw materials and spares in heavy engineering group were correlated with their usage and those of work-in-process and finished goods with cost of sales according to the linear model $I = a + bs$ through regression analysis in six combination of years

1 to 7, 1 to 8, 1 to 9, 1 to 10, 1 to 11 and 1 to 12. The important results of these regressions are summarised in Table 4.

Table 4

Simple Regression of Inventories to Usage : $I = a + bs$.

Parameters for Analysis	1966-67 to 1977-78			1966-67 to 1974-75		
	Raw Materials & spares	Work-in-process	Finished Goods	Raw Materials & spares	Work-in-process	Finished Goods
1	2	3	4	5	6	7
No. of observations	12	12	12	9	9	9
a—coefficient	35.64	26.55	—4.23	29.10	0.93	—3.33
standard error	5.18	10.12	8.46	5.54	7.36	7.28
t—value	6.88	2.62	—0.50	5.25	0.13	—0.46
b—coefficient	0.7285	0.3127	0.4242	0.8114	0.5350	0.3994
standard error	0.0238	0.0313	0.0262	0.0473	0 0469	0.0464
t—value	30.582	9.98	16.20	17.15	11.42	8.62
R^2	0.995	0.953	0.981	0.977	0.949	0.914
F--variance ratio	934.94	99.55	262.41	294.02	130.41	74.25

The regression of crude materials show positive intercept 'a' significantly different from zero at 95 percent confidence in all the six combinations of years. The reaction factor b is also positive. The R^2 value is more than 0.97. All these give strong evidence of economies of scale. In inventories of work-in-process and finished goods intercept 'a' is not significantly different from zero at 95 percent confidence. The R^2 is more than 0.9 in all the six groups of years for work-in-process stocks. For finished goods R^2 is more than 0.9 in the last four years of combination. These facts show that the inventories of WIP and of finished goods on the whole, had not taken advantage of economies of scale, and moved in constant ratio with the sales because here intercept 'a' is approaching zero.

Model II : The alternative theory to model I is that inventories are a square root function of sales/usage (i.e. $I = a + bs^{\frac{1}{2}}$). Regressions were run again for each of the three kinds of inventories in the same correlation as in the model I and important results are set out in Table 5.

For inventories of Raw materials in all the six groups of years R^2 is more than 0.93 and intercept a is negative, but is not significantly different for zero in years 1 to 7, 1 to 8 and 1 to 9 and in the remaining three groups of years it is significantly different from zero. For the last three groups of years it is further seen that the mean value of s is greater than the model value of $4a^2/b^2$. The coefficient 'b' is positive and is significantly different from zero at 95 percent confidence in all the five groups of years. These facts show that in this category of inventory the time series data have responded favourably to the square-root relationship upto first nine years, but when 1 to 10, 1 to 11 and 1 to 12 years were taken the model failed to catch reality. In the WIP the intercept 'a' is negative and significantly different from zero at 95 percent confidence, R^2 is more than 0.9, 'b' is positive significantly different from zero but the mean value of $s > 4a^2/b^2$ of the model. All these facts prove that in this component of inventories the square root relationship model does not capture reality. As such no conclusion can be drawn from this model for WIP. In finished goods inventories, the R^2 is very low in all groups of years except the last two groups of years and hence no conclusion. During the last two groups of years R^2 is reasonably high 'a' is negative, and 's' is less than $4a^2/b^2$. These facts show positive response of this model to the data. But R^2 of the model I is higher than that of the model II. Under these circumstances greater reliance

Table 5

Regression of Inventories to Usage : $I=a+bs^{.5}$

Parameters for Analysis	1966-67 to 1977-78			1966-67 to 1974-75		
	Raw Materials & Spares	Work-in-process	Finished Goods	Raw Materials & Spares	Work-in-process	Finished Goods
1	2	3	4	5	6	7
No. of observations	12	12	12	9	9	9
a—coefficient	—56.27	—42.33	—89.37	—35.97	—62.75	—48.34
standard error	24 37	9.26	16.50	15.31	12.49	15.22
t—Value	— 2.73	— 4.57	— 5.42	— 2.35	— 5.02	— 3 18
b—coefficient	18.30	10.3015	13.3813	15.6823	12.4129	9.0296
standard error	0.9371	0.5958	1.0611	1.5828	1.0984	1.3384
t—Value	19.53	17.29	12.61	9.91	11.30	6.75
R^2	0.987	0.984	0.970	0.933	0.948	0.867
F—Variance Ratio	381.26	298.91	159.03	48.17	127.71	45.52

is to be placed on model I. The preceding analysis indicates that in all these categories of inventories for the period as a whole, the exponent of 's' is likely to be more 0.5.

Model III : The model $I=\alpha S\beta$ with β lying somewhere between 0.5 and 1 indicates economies of scale but these economies are not as great as those indicated by the square root formula. Linear regressions on this model equation were calculated in the logarithmic form $\log I=\log_\alpha+\beta \log S$. The results of regression for each of the three components of inventories in the same correlation as in the previous two models are indicated in Table 6.

As far as inventory holding of materials is concerned there is strong evidence of economies of scale. The value of β for the period as a whole is more than 0.5 and less than one being nearly 0.66 and when judged from the 't' value it is significantly different from zero. The R^2 value is very high. In the stocks of WIP, the economies of scale are very mild over the period as a whole as β is 0.88. The analysis of results of first three groups of years 1 to 7, 1 to 8, and 1 to 9, show that β is not significantly different from one at 95 percent confidence.

The R^2 is more than 0.97. All these show that WIP had been moving in constant ratio with value of produce. It is only with the additions of 10, 11 and 12th years that extremely mild economies of scale are observed. In the 10th year two new undertakings were added to this group. These contributed Rs. 33.57 crores and Rs. 37.12 crores to cost of sales and work-in-process respectively. But for the addition of these two enterprises the economies of scale would have been slightly more than those now seen. These facts fortify the conclusions drawn from the results of application of model I, and do not conflict with those of model II.

It is seen that in inventories of raw materials the management had taken advantage of substantial economies of scale which were in the neighbourhood of square root relationship during the group of year 1 to 7 and 1 to 8, and subsequently the gains of economies of scale did remain but were not to the extent observed in earlier years. In the category of semi-finished goods, the stocks, on the whole, moved in constant ratio with sales except for the mild economies of scale achieved in the 10th and subsequent years of study. The results of regression analysis according to model III for finished

Table 6

Regression of Inventories to Usage : log I=log α + β log S

Parameters for Analysis	1966-67 to 1977-78			1966-67 to 1974-75		
	Raw Materials & Spares	Work-in-process	Finished Goods	Raw Materials & Spares	Work-in-process	Finished Goods
1	2	3	4	5	6	7
No. of observations	12	12	12	9	9	9
β	0.6642	0.8839	1.0978	0 6127	1.0629	1 0811
standard error	0.0302	0.0569	0.0663	0.0445	0.0546	0.1150
t—Value	21.97	15.54	16.55	13.77	19.45	9 40
logα	1.73	— 0.16	— 1.48	1.93	— 0.93	— 1.42
standard error	4.63	7.97	5.88	5.60	4.56	4.10
t—Value	0.37	— 0.02	— 0.25	0.34	— 0.20	— 0.34
R^2	0.990	0.980	0.982	0.964	0.982	0.926
F—Variance ratio	482.86	241.47	273.94	189.75	378.27	88.30

goods inventories, gave β slightly more than one in all the six combinations of years. R^2 was more than 0.92 in the groups of years of 1 to 9, 1 to 10, 1 to 11, and 1 to 12. These indicate symptoms of diseconomies of scale. On application of further tests it was found that the differences between β value and one was not significantly different from zero at 95 percent confidence. So it will be safe to conclude that in finished goods inventories there had been no economies of scale and growth had been in constant ratio with cost of sales. This conclusion is further strengthened by the results of application of model II.

Impact on All Inventories : The results of regression of all inventories against cost of sales showed strong evidence of existence of economies of scale on the whole but not to the extent given by square-root relationship. The results of model II showed negative intercept and in most of the years $S > \frac{4a^2}{b^2}$, thus indicating that the exponent S value is more than 0.5. The model I gave positive interceptvalue significantly different from zero at 95 percent confidence level for 1 to 7, and 1 to 10, 1 to 11 and 1 to 12 years. The R^2 was more than 0.96. These facts give evidence of existence of economies of scale. It is further corroborated from the Fig. 5 which depicts relationship of cost of sales and average inventories over the period under study.

Among the six groups of years the application of model III gives minimum value of β coefficient at 0.784 for first seven years and maximum at 0.865 for decade. The multiple coefficient of correlation R^2 was very high being more than 0.97. These facts together with the results of application of models to the three components of inventories show that there had been economies of scale in the holding of stocks as a whole and, secondly, the economies of scale achieved through management of raw materials were large enough to offset the impact of increase in inventories of WIP and finished goods in constant ratio with value of produce.

Excess Holdings

The applications of models give evidence of some rationalisation in the management of inventories at aggregate level and of raw materials, but no such evidence could be gathered through application of models to WIP and finished goods inventories separately. The models also did not assist in assessing the excess inventories on any date. An approximate idea of the excess holding can be formed through analysis of growth rates on the assumption safety stocks and policy variables have not changed over the last eleven years. [The mechanics of working out excess holdings were explained in paras on pages 323-325 of the article published in *Productivity*, October-December, 1978].

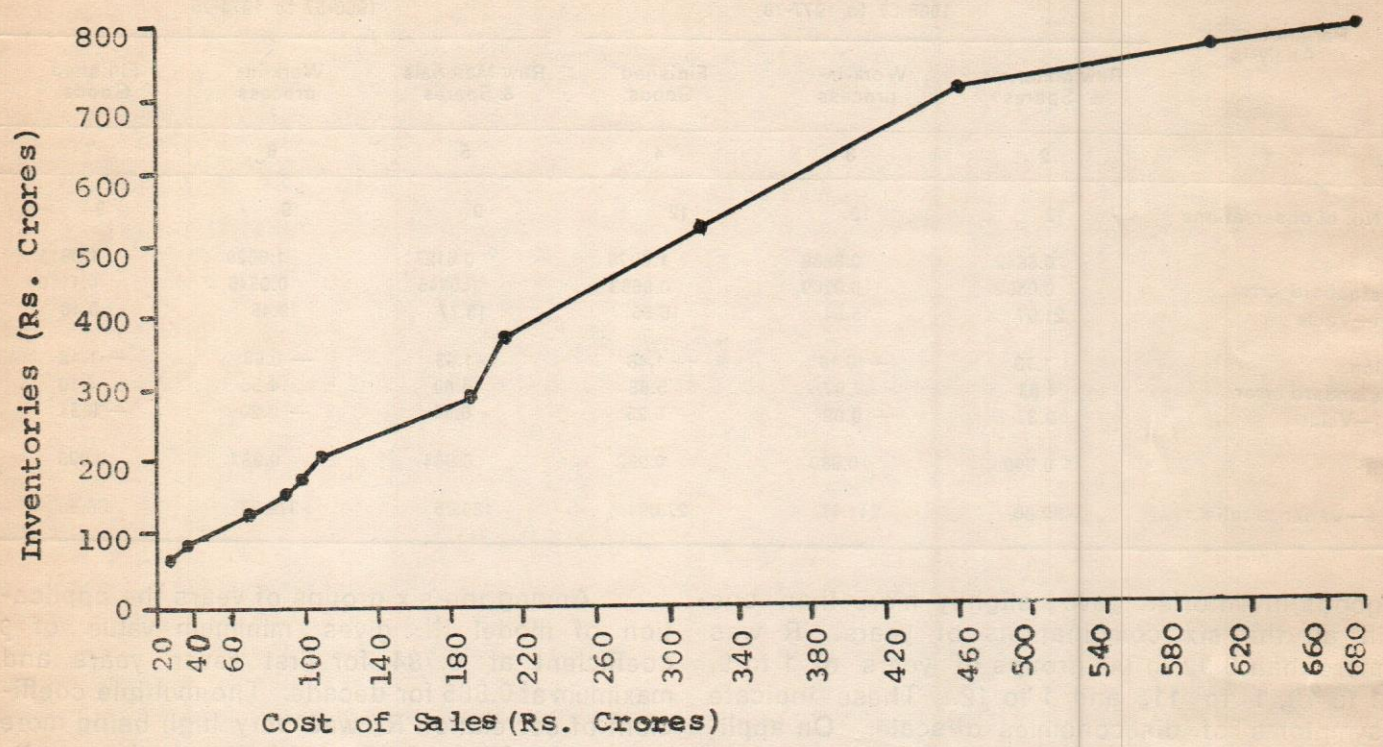


Fig. 5 All Inventories & Cost of Sales Relationship—Heavy Engineering

Analysis of Growth Rates : During the period under study the value of produce and total inventories respectively grew at 33.11 and 26.94 percent. If inventories had moved in the square-root relationship of the cost of sales the growth rate would have been ($\sqrt{1.3311}-1$) X 100, i. e., 15.37 as against the actual rate of 26.94 percent. On the basis of the methodology referred to in the preceding para the excess stocks of all the inventories in the last year of the study as compared to those required under ideal conditions of square-root relationship are worked out at 55.78 percent i. e., Rs. 437.70 crores out of total holding of about Rs. 784.8 crores in 1977-78.

Experience has shown that a reduction of about 20-25 percent of stocks is within easy reach of management through modern inventory techniques. Even with this standard about Rs. 157-196 crores of capital can be released for active use apart from saving 10 to 15 percent of annual carrying cost of stocks.

Case Studies

In this group of 10 enterprises, four indepth studies have been made by the Committee on Inventory Control. These relate to (i) Heavy Engineering Corporation—Heavy Machine Building Plant (HMBP) Ranchi; (ii) Heavy Electricals India Ltd., Bhopal, (iii) Bharat Heavy Electricals Ltd. High Pressure Boiler Plant Unit, Tiruchirapali; and (iv) Bharat Heavy Plate and Vessels Ltd., Vishakapatnam. The Committee on Public Undertakings studied the management of inventories (as part of general working) in Mining and Allied Machinery Corporation Ltd. In addition, BPE in its Annual Reports for Central Government Enterprises reviews every year the position of inventories.

On the basis of certain norms laid down by the Committee or Inventory Control, these studies revealed existence of excess inventories between 28-50 percent of the total stocks in different

years of study in some cases. The main reasons of heavy accumulation of inventories in raw materials were : (i) the production was job based and that necessitated stocking of different types of items, (ii) procurement of material against work order had been usually made in one lot despite the fact that the execution of work was spread over 2 to 3 years, (iii) there was gap between planned and actual production and procurement of inventories was based on budgeted production in advance of about 2 years, and (iv) heavy dependence on imported materials which took generally 18 months. Some times purchases were made on barter basis in wider interest of country in some case on the advice of foreign collaborator and in both the cases these added to stock piling. The quantum of work-in-process was high due to the reason that these undertakings were manufacturing a wide variety of heavy equipments whose manufacturing cycles varied from a few weeks to a few years. The heavy inventories could also be the result of job works as these are clarified so that a large part of the contract value is received in initial years and thereafter urgency of early completion of work is reduced. In some cases the main reason of heavy stocks of finished goods was that customers who happened to be public undertakings wanted to withhold despatches for shortages of funds. Despite repeated disposal of surplus stocks as revealed by the Annual Reports of Bureau of Public Enterprises, these undertakings carried huge stocks of more than 2 years non-moving items. The Committee also identified the need to reduce the number of financial checks, prepare catalogue for variety reduction and standardisation and have scientific reporting system for enabling the top management to watch inventory performance. Emphasis was laid on the need to streamline the system of locating surpluses and arranging for their disposal.

Conclusions

The behaviour of different components of inventories in enterprises engaged in manufacture of heavy engineering equipment was analysed through trends in turnover rates, comparison of inventory investments over the period, regression analysis according to the three pre-conceived models, analysis of growth rates and findings of indepth case studies. The results obtained are consistent in respect of the following conclusions :

(i) This group of enterprises carried stocks more than the cost of sales in all the years of the period under study.

(ii) The level of holdings and inventory turnover ratios over the period show that during the last few years lesser volume of stocks supported larger sales as compared to stocks in initial years. The economies of scale made, were, however, not so high as those indicated by the square-root relationship. In the terminal year of the study this group of enterprises held nearly 56 percent of excess stocks as compared to the inventories required under ideal conditions. If the redundant stocks of initial year are also taken into account the excess inventories in the last year will be still higher.

(iii) Indepth case studies conducted by the Committees on inventories control of BPE, show that inventories of all the categories are ill managed. Redundant holdings were discovered in a large number of items and at aggregate level the excess holdings vary between 28 to 50 percent as compared to certain norms fixed by the Committees.

(iv) Experience has shown that a reduction of about 20 to 25 percent of stock is within easy reach of management through modern inventories techniques. With this standard about Rs. 157 to 196 crores of capital can be released for active use, apart from saving 10 to 15 percent of annual carrying cost of stocks.

(v) Comparison of sales to inventories ratio in this group of enterprises with american and the large-sized private sector joint stock companies of India show that the performance of inventories in Central Government Public Sector enterprises in heavy engineering group needs to be significantly improved.

(vi) The applications of models reveal different behaviour by the three components of inventories. The inventories of crude materials have, on the whole, shown economies of scale but

these are not equal to what is given by square-root relationship. The inventories of WIP and finished goods do not give any evidence of operation of the law of economies of scale.

(vii) The WIP and finished goods inventroies on the whole have moved in constant ratio with cost of sales except in case of WIP during the period of last three years when mild economies of scale are seen.

(viii) The main reasons of excessive WIP stocks are long production cycles, and the practice of designing the term of payment in such a manner that a large part of contract value is received in initial years and thereafter urgency of early completion of work is reduced. The heavy stocks of finished goods in many cases were mainly due to the reason that customers who happened to be public undertakings wanted to withhold dispatches for shortages of funds. The efforts for reduction in these two categories of inventories are to be made by the management of the organisation and through intervention of the Government.

(ix) The evidence here supports the hypothesis, that the level of inventories is higher than what is required for efficient production. The evidence also shows that during the period under study, particularly in the last four years some rationalization in the inventory policies has taken place, but still there is scope of further reduction in stocks. Thus, wide publicity given during the last decade to the application of inventory models had positive impact on reduction in inventories level particularly those of raw material and spares. □

Productivity
1981, XXII, 1, 35-38

Activity Sequence Analysis A Technique To Increase Production

R. P. NADKARNI
National Machinery Mfrs. Ltd., Bombay

Activity Sequence Analysis and Method study cut down the distances traversed by 40% and released 18% crane hours for loading and unloading components of the production machines. They obviated the purchase of a new crane and enhanced production.

"The overhead cranes are my bottle-necks. The two that are there aren't sufficient at all. They are heavily occupied in transporting material. I am losing at least 15% of my machine hours waiting for a crane to be free for loading or unloading my machines" rattled off the foreman of our Heavy Machine Shop when asked by his manager to explain the shortfall in production.

"What solution do you suggest ?" countered the manager.

"Give me one more crane and there will be no problems" replied the foerman.

"May be. But do you appreciate that it would cost a tidy Rs. 200 thousand in addition to an annual burden of Rs. 30,000 by way of new cranedrivers' salaries ?" asked the manager.

"How about asking our industrial engineer to look into this ?" suggested the foreman.

"That's a good idea" said the manager reaching for the telephone.

"I would like you to study the workload of our cranes. Would you mind seeing me ?"

This was the background when the author undertook the study.

Objective

The aim of the study was to make the existing cranes adequately available to load and unload

components off the machines thereby avoiding the purchase of a new machine.

Activity Sequence Analysis

It was during this study that the technique of "Activity Sequence Analysis" was evolved and employed profitably together with the traditional method study.

The steps in using the Activity Sequence Analysis technique are :

1. List down components to be processed.
2. Denote by numbers the various activity centres i.e., locations of machines used for processing the components, locations of inspection benches, locations of material pools.
3. Against each component, mention the activity centre numbers in the sequence of occurrence of the activities. The numbers thus form a sort of numeric code for each component and represent the process route of the component. So long as components have similar activity sequence code, Activity Sequence Analysis regards them as similar, irrespective of their physical features.
4. Compare the numeric codes of all components with one another.
5. Group together components having similar activity sequence codes.
6. Compute operational load (machine hours) on the machines for the targeted output using operation timings for the components.
7. Based on the code grouping and machine-hour loads, rearrange the activity centres to minimise the distances traversed by components while ensuring balanced machine loads.

Use of ASA

(Table 1 lists for illustrative purpose

Table 1

Illustrative List of Components

Description	Location and Sequence of Activities (Present)							
	Door-Way	Pool	Grind	Mill	Drill	Inspe-ction	Weld	Inspe-ction
Component a	1	2	9	10	12	17	16	17
Component b	1	2	9	10	12	17	16	17
Component c		2	9	11	7	17	16	17
Component d	1	2	9	11	7	17	16	17
Component e	1	2	8	14	12	17	16	17
Component f	1	2	8	15	13	17	16	17
Component g	1	2	8	14	13	17	16	17
Component h	1	2	8	15	12	17	16	17

Notes : See Layout Drawing No. 1 in conjunction with Table 1

Activities 12, 7, 13 are considered equivalent to each other

Activities 10, 11 are considered equivalent to each other.

Activities 14, 15 are considered equivalent to each other.

only few of the forty components processed in the machine shop. Layout Drawing Fig. 1 shows the respective activity centres.

A close examination of the activity sequence codes and the movements of components on the shop floor revealed that

a) the shop layout involved excessive movement between work zones X and Y,

b) an additional crane would cause a physical interference with other cranes because the cranes ran on common overhead girders. Buying a new crane was, therefore, not at all advisable.

This meant that the inter zonal movement of the cranes had necessarily to be reduced. This was achieved by methods improvement (compare Layout Figs 1 and 2).

a) Machines 8 and 7 were relocated (Fig 2). Since all production machines were heavy, only two were shifted to minimise the cost of shifting and interruption to production, though this admittedly was not the ideal solution.

This enabled one group of machines to process a certain 'family' of components having similar activity sequence codes (see Table 2) within one work zone X independent of another group of machines working in the other zone Y. Each zone could be serviced by a separate crane without interference.

b) Certain long components that could not be transported by a forklift through the narrow doorway B (Fg. 1) used to be brought through the wider doorway A, unloaded at location 1 and transported by one of the overhead cranes to location 2. This put an undue load on the cranes. It was avoided by widening the doorway B (Fig.2). Long components could then be unloaded directly at location 2, thus eliminating the corresponding load of transportation from the cranes.

c) Inspection and welding activities were decentralised. (Fig. 2). An electrical point was provided near each inspection bench to eliminate the to and fro move-

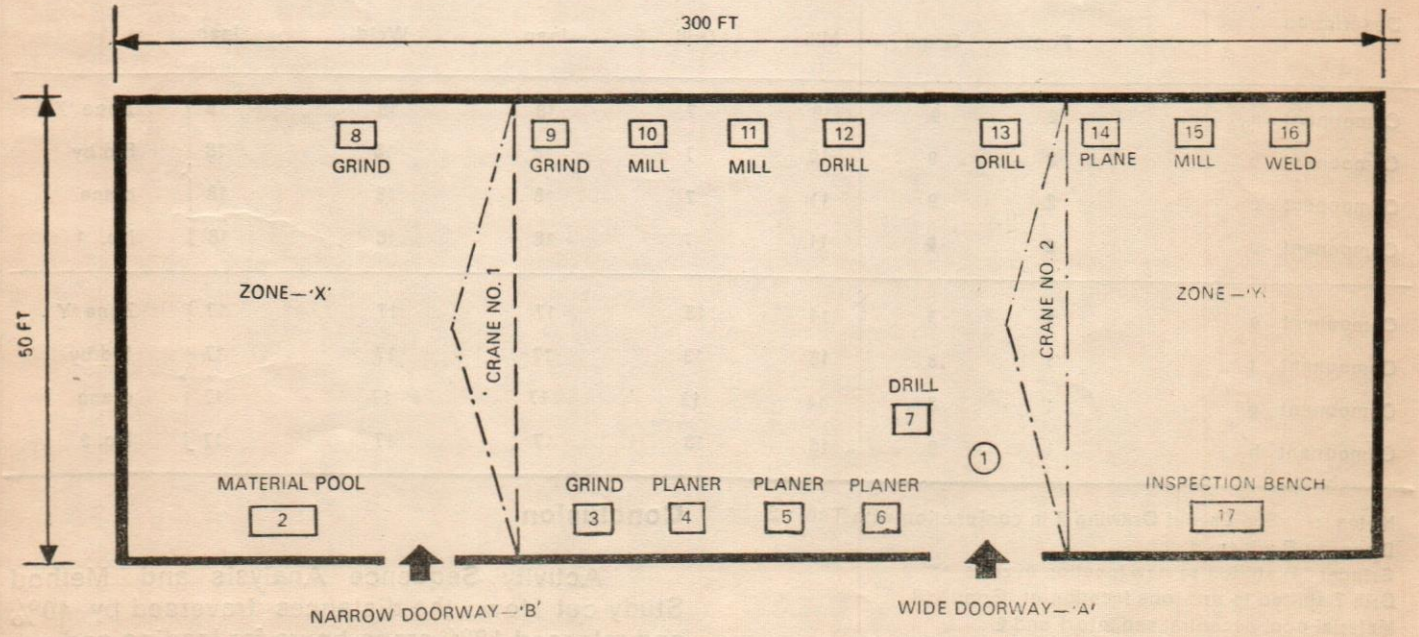
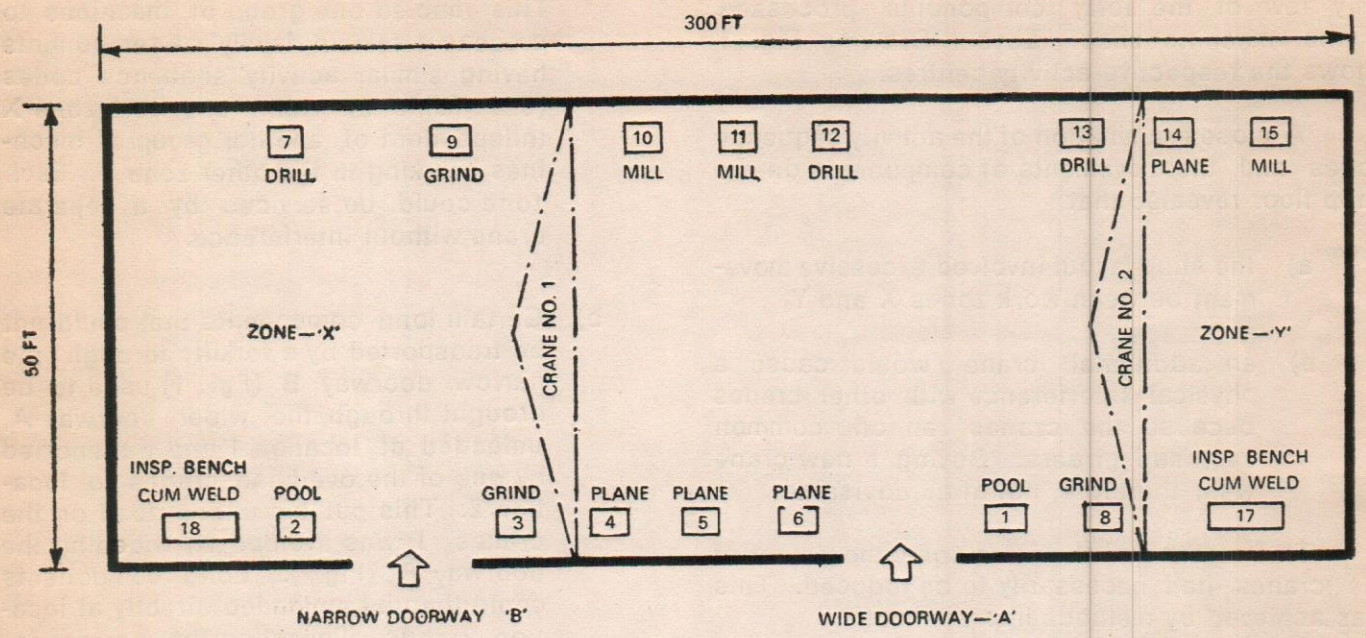


Fig. 1 Schematic Layout Drawing No. 1 (Not to Scale)



NUMBERS WITHIN INDICATE ACTIVITY LOCATION

Fig. 2 Schematic Layout Drawing No. 2 (Not to Scale)

Table 2

Relisted Components

Description	Location and Sequence of Activities (Proposed)							
	Pool	Grind	Mill	Drill	Insp.	Weld	Insp.	
Component a	2	9	10	7	18	18	18	Zone 'X' fed by crane No. 1
Component b	2	9	10	7	18	18	18	
Component c	2	9	11	7	18	18	18	
Component d	2	9	11	7	18	18	18	
Component e	1	8	14	13	17	17	17	Zone 'Y fed by crane No. 2
Component f	1	8	15	13	17	17	17	
Component g	1	8	14	13	17	17	17	
Component h	1	8	15	13	17	17	17	

Notes : See Layout Drawing 2 in conjunction with Table 2
Doorway B widened
Grinder B shifted to new location in zone 'Y'
Drill 7 shifted to previous location of Grinder 8
Material pool decentralised into 1 and 2
Additional Inspection Bench provided near Material Pool 2
Welding point provided near each Inspection Bench

ments of cranes between inspection and welding activity centres.

Conclusion

Activity Sequence Analysis and Method Study cut down the distances traversed by 40% and released 18% crane-hours for loading and unloading components off the production machines. They obviated the purchase of a new crane and enhanced the production. Both the manager and the foreman were a happier lot. □

Productivity
1981, XXII, 1, 39-48

Technological Forecasting In India

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Technological forecasting is not the prediction of the dreams of the 21st century, but is a useful concept to consider possible, probable & feasible product/process options of the future. These are objective inputs to reduce the long-term risks involved in long-range decisions. The major success of TF lies in generating newer alternatives from which selection can be made based on rational criteria.

Technological Forecasting (TF) was evolved as a planning tool in the sixties and seventies in the defence, Long Range and R&D planning sectors. In India this tool has not become a widely prevalent technique because of many a misconception. It is, therefore, necessary to clarify the misconception and identify its utility in various enterprises and how best TF can be applied in Indian conditions.

PREVALENT MISCONCEPTIONS

1. TF is useful only to large Companies

Many practicing managers consider TF as a crystal-ball gazing technique useful to large corporations. Whereas, it is an area which uses a number of techniques for creating new ideas, solving problems, design optimisation, value engineering and for identifying newer alternatives, Design Engineers, Marketing Managers, Materials Managers, Purchase Managers, etc., have also benefited from TF techniques. It is often said that Technology Forecasting is an attempt to predict utopian technologies that are likely to be developed in the 21st century and beyond. This is not true because technology is used in general, encompassing product development, process development, improvements in design, packaging improvements, research methods, and cost reduction and it is in these areas that TF can be used for a wide variety of purposes at different levels, from the board room to the design engineers room effectively.

2. TF techniques are all sophisticated and small companies cannot afford the use of these.

TF techniques are objective methods which are taught and learnt easily, amenable to use effectively at all levels, subject to review and verifiable by the superiors, TF techniques can also be practiced easily, provided there is adequate data to proceed. Engineers, economists and statisticians can pick up TF techniques, without much difficulty.

3. Predicting technology is not reliable, since breakthroughs cannot be anticipated.

TF is only a way to reduce uncertainty and is not a guarantee against risk. Anticipating technological threats, product competitions, obsolescence and performance risk and the like can help in improving decision-making under competitive environments. TF is an early warning system or a technological environment scanning radar. Japanese have a well developed technological intelligence system, which is capable of providing data on new products, processes, patents, developments and licences. Developing a good technological base is a pre-requisite for development and a technology intelligence system is a pre-requisite for a technological plan. For a fast moving fighter aircraft, forward looking, side looking radars are a must and for a fast moving company an environmental scanning system is a must and TF is the basis. In other words, one reduces the risks by using these techniques if not altogether eliminate them.

4. TF is not a cent percent successful method.

Information for decision making cannot be evaluated easily for success and failure. TF is an input for corporate decision making process and is not a substitute for a decision. The major success of TF lies in generating newer alternatives from which selection can be made based on rational criteria. Any forecast can be described as a vector of two properties, the precision and reliability. TF mainly helps in increasing the reliability or the credibility characteristics of forecasts as opposed to precision which deals mainly with the pointedness of forecasts. For long term forecasts one needs reliability more than precision whereas short term forecasts rely more on precision. Computerisation can only increase the precision of forecasting but TF helps in improving the reliability component. In rapidly changing environments no technique can be 100 percent successful.

5. TF is useful only to technology oriented organisations and not to service organisations like Electricity Boards, Railways, Road Transport Corporations, Posts and Telegraphs etc.

This is yet another misconception. Railways, Post and Telegraphs, Electricity Boards etc., can achieve cost reduction using TF techniques. Further, rate of obsolescence can be reduced and modernisation can be accelerated. Exposing senior managers of service organisations involved in planning to TF techniques, can help them to mitigatet heir fears about change. Changes cannot be introduced unless the system managers understand the need for change. In fact, TF and long range planning are needed more in service organisations. Bureaucracy has an inherent property of resisting exogenous changes and only endogenous improvements would be acceptable.

6. TF is a one shot technique.

Some organisations consider that once they do TF it is enough for years to come. TF must be used as a continuous input into the corporate planning exercise. Every year the forecasts should be reviewed and updated. In short, TF exercises should be done at regular intervals for preparing the corporate plans. In every long range planning group, there must atleast be one person who regularly looks ahead to identify, evaluate and assess new product or new process information.

7. Companies with foreign collaborations cannot utilise TF at all.

TF has been wrongly perceived as a technique for predicting fantasy technologies of no immediate consequence to the organisation. TF is a package of techniques and can be of use in predicting new product demand, technological substitution, market penetration, product obsolescence, etc. In fact, TF has been defined as a method of predicting future performance characteristics of useful machines, procedures and systems. Fantasy predictions are precluded from the pur-

view of TF and only down to earth practical methods of immediate use to practising managers are included. Companies with foreign collaborations, can also use TF in market share analysis, cost reduction, design improvements and diversification analysis. In fact, TF techniques can be of help in increasing the rates of import substitution.

8. TF can be done independently without linking with a corporate Plan.

This is the most dangerous misconception of all. Technological forecasting is not a futuristic exercise in futility. On the contrary, it is an input into managerial information for long range planning. If TF is to be useful to an organisation the first prerequisite is a long range plan. TF is used iteratively to derive long rang policy objectives, long range product plans, long range production plans, diversification plan, long term market plans and R&D plan. Unless there is a good corporate planning system, there is no use of having technological forecasts. The long range forecasts and plans are linked through strategic and operational plans. A useful and meaningful long range plan cannot be derived without a good TF input. Technological forecasting is not the prediction of the dreams of the 21st century, but is a useful concept to consider possible, probable and feasible product/process options of the future. These are objective inputs to reduce the long term risks involved in our long range decisions.

It can, thus, be observed that TF is a useful concept for planning. However, before considering the applications of TF, it would be useful to answer questions such as what makes it necessary to have this new technique, is it not possible to manage with the older methods, etc. In the recent years, technology is becoming a major factor to be considered in planning process. This aspect is considered in detail in the following paragraphs.

IS TECHNOLOGY A MAJOR FACTOR ?

Technology was not considered a major factor by multinational companies (for their Indian operations), companies with foreign collaborations, and small scale companies (their operations were mainly short term oriented), of course, with difference in bias towards various objectives. The Indian companies, especially the private ones, did not attach much importance to corporate technology problems. The problem started looming large as soon as giants started competing with multinationals or transnationals. The main eye opener was the factor that some Indian companies with their own technology could grow comparably well with others even though they were small in size. This has been mainly due to the fact that technology has become a power-parameter.

1. Technology capabilities grow exponentially.

The technological capabilities or system characteristics grew exponentially with time; for example, our energy requirement, generation capabilities, electric motor production, fertiliser production, air transport capacity, etc. Exponential nature of growth has made it necessary to look into the complementary areas like marketing, production, material and manpower requirements, process techniques, finance, investment decisions and competitions.

2. Linearity of human perception.

Human planning is optimistic in the short run and pessimistic in the long run, This shortsightedness arises because systems demand grows exponential whereas human perception which is linear lags behind systems demand leaving a big performance gap in the long run. Many examples of this can be sighted in the Indian scene, e.g. power shortage, transportation over-crowding in cities, shortages, etc.

3. Corporate competition.

Between business organisations there is a severe competition, and to remain a leader in one's product area, one has to look farther than what one's competitor perceives. On the export front also, competition exists among various countries. If India has to remain a leader in leather exports, it has to look ahead anticipating technology changes in leather industry as well as in competing industries.

4. Shift to large scale systems.

The present tendency is to go in for large scale production systems. This implies commit-

ment of more resources from which one cannot go back easily. Damages in larger systems will be costlier. For instance, if one is going in 500 MW generating systems, the reliability of such a system should be much more than the conventional small sets; otherwise power shortages can be of very high magnitude.

5. Obsolescence means collapse.

The innovations that are taking place in each area are increasing rapidly. Firstly, the number of research personnel has increased manifold. Secondly, the innovative skill of each person has improved because of (a) quicker information dissemination techniques all over the world, and (b) new computation tools or better precision instruments. The synergistic combination of these makes way for newer, better and cheaper products. This effect is perceptible in marketing efforts of companies directed towards market segmentation. Introduction of new technology means complete collapse in some cases of investments. Cases of investment decisions without any concern for technology have been on the increase. The cost of stainless steel produced in the ASP, Durgapur, based on an old technology without looking ahead had made it a losing venture. Similar short horizon decision making has been made in a large number of organisations in India. Old abrasive units have become obsolete because silicon carbide technology has been initiated.

Another glaring example of this in India is seen in the textile industry. A number of textile units have become sick because of non-availability of funds for modernisation, i. e., mainly due to obsolescence. Even large units established earlier could not compete successfully with the modern units. This is because technology was never considered a major parameter by these units earlier. If such a state of affairs is not to repeat in other sectors, one has to consider possibilities of changes in technology in the corporate sector.

6. Emphasis on appropriate systems.

Today, there is a bias towards decentralised production or small scale production. Some sectors have been reserved only for small scale production. This makes it necessary to look into the economics of scale of various technologies. Further, this also forces every corporate planner to anticipate change in technologies which may shift economics of scale. Appropriatness is a very subjective area and planners have to look ahead.

Transportation and communication systems are mutually substitutive and this is of significance to a country like India. Transportation is 100 times more energy intensive than communication and one should look systematically into these kinds of appropriate options.

7. Resources are becoming scarcer.

It is very essential to look into resource utilisation because, the world over, resources are becoming scarce. Processes likely to consume less resources are always more profitable. Resource productivity, energy efficiency, etc., become factors in corporate choices. Changes in casting technology, manufacture of non-machining products, etc., have been mainly technology changes initiated by process efficiency. Plastics are preferred to metals because the energy costs of recycling by remelting favour the former.

8. Multiplicity of generation of Technologies.

Under conditions of fast technological changes, in many organisations there are situations where multiple technological generations are maintained. For example in the Indian Railways there are routes in which steam, diesel and electric traction are operating side by side. Similar situation exists in the Indian Airlines and their fleet consists of different generation planes like HS-748, DC-3, Caravelle, Fokker Friendship, Boeing 737, Airbus-300 etc. Another example is the telephone system where different levels of equipments exist involving three generations (like vacuum tube equipments, transistor equipments and IC equipments). Maintaining this type of different generations alongside escalates the operating costs, inventory costs, labour costs and decreases the system efficiency. Detailed long range exercises are necessary for any organisation to have an effective system. Unless long range corporate planning involving technology options is initiated, large scale systems will be operating far below their optimum efficiency.

9. Environment is dynamic.

The governments and their policies change very often in the states as well as at the centre.

The policy making process in India is so individualistic that industrial policy, licensing policy, pricing policy, raw materials policy, etc., change very frequently, mainly in opposite directions. This has made it necessary for the planners to go in for technology systems which are more adaptable; for example, the fuel policy in India changes often and dual firing burners capable of using oil or coal are suited than one technology choice option. This, obviously, may clash with resource efficiency and the corporate planner has to be more sensitive to technology.

These are the necessary and sufficient conditions why technology choice interacts with corporate strategy so strongly. This has made it necessary to introduce technology planning into the corporate strategy.

APPLICATIONS OF TECHNOLOGY FORECASTING

Corporate strategy incorporating technological forecasting has been referred to as technological planning, i. e., considering technology as a decision variable. This approach has many advantages compared to purely economic or financial approaches assuming technologies to be static.

1. To initiate long range planning.

To initiate long range planning, we need better perception or field of vision, and technological forecasting can clarify our field of perception. Conceptually, long range planning involves bigger changes involving technology, products, attitudes, social systems, resource consumption patterns, government policies, etc. Most of the Indian corporate planning exercises have been aimed at vertical diversification than horizontal diversification or functional diversification. For example, an electronic data processing unit is planning its diversification. Functional diversification involving data processing, like library documentation, computerised health systems, educational technology, soil diagnosis systems, etc., may be more broad-based rather than moving in the data processing part alone.

2. To avoid surprises.

To be caught unawares by the changes can be avoided by anticipating changes in the environment and specific technology areas. Conventional polyethene manufacturers and metallic component manufacturers have to anticipate the effect of large scale production of polypropylene which is superior. TV industry has to be carefully watching the CD technology since introduction of TV based on LCD will make TV based on cathode tubes obsolete.

3. To leap across generations.

One of India's major problems is the existence of a technological gap in areas such as computers, generators, fertiliser plants, etc. Technology Forecasting will help in the identification of newer systems so that skipping of one intermediate generation is possible. For example, consider the aluminium industry; while improving the present system India should develop the third generation process (non-electrolytic, direct reduction process). These forward leapings will reduce technology gaps.

4. To extend the planning horizon.

The corporate planning horizon in our country is about five years and any efforts to have a longer range of plan will have to use technological planning. This is done by anticipating crises or threats and converting them into opportunities. For example, suppose there is a likelihood of a material crisis in the near future. In such a situation, detailed plan has to be made in the area of material recycling, material conservation and waste reduction. Such deliberate exercises will have to be done so that planning horizon is extended.

5. To provide non-obsolete training.

One of the major problems of our country is training the professionals. Because of the rapid changes in the technologies and support systems training becomes obsolete quickly. TF tries to correct this lacuna by assisting to identify future technologies and support systems. Engineers, technologists and managers who are likely to be the top level decision-makers in the year 2000 may be the people who are undergoing learning in the current systems. Introduction of newer technologies will help in providing non-obsolete training which is conceptually difficult to provide. For example, instructions in solar technology,

computerised information dissemination, etc., have to be provided today in the current training.

6. To be a leader.

One who does not look ahead will find himself far behind sooner or later. Companies all round the world involved in systematic long range planning continue to be the leaders as compared to the bigger and conservative systems or even multinational companies. The Indian company which developed the production of rayon grade pulp from bamboo and Eucalyptus is still the leader in its sector. It is transferring technology to countries like Malaysia. In India itself, the process has been improved to utilise other varieties of wood since bamboo is in short supply because of its use in paper industry. In another case, one Indian company has foreign collaboration and its foreign collaborators abroad were absorbed by another company in England. This company which absorbed the foreign collaborator was the competitor of the Indian company. The Indian company managed to go alone because of its looking ahead in technology.

In the area of fertilisers, algae additives are found to increase the fertiliser effectiveness. There is likely to be a threat to the fertiliser industry since nitrogen is the basic input in cereal crops. The strategy should be to develop algae, P mixtures and nitrogen fixing bacteria packages. Addition of nitrogen fixing bacteria can impart nitrogen fixing capabilities in certain cereal strains. So, to be a leader, one has to look ahead in technology.

7. To be an eternal exporter.

Exporting to markets abroad requires extending the field of vision in two dimensions, i.e., offensive planning as well as defensive planning. Anticipating the performance of competitors' products will help in providing entirely different range of products, i.e., offensive planning. Defensive planning involves improving one's own products so that they are better than that provided by the competitor. To remain as an exporter, it thus requires (a) development of entirely new products, mainly functional diversification or horizontal expansion, and (b) development of improved products in the vertical path, i.e., in the same product line. The markets abroad may change faster, hence resilience is another chracteristic which is needed. Resilience may mean easy change of production pattern, product pattern, and distribution pattern in the wake of fluctuations in export market. HMT and BHEL are major Indian organisations which undertook detailed technological forecasting studies so as to remain as pace setters. This awareness among the corporations proves the significance of technology inputs.

APPLICATIONS FOR CORPORATE PLANNING

Technological forecasting can be used in corporate planning at the policy, strategy and operational levels. The various steps involved and the examples are given in Table 1. Technological forecasting will be of use in all the three levels. TF can be used for the following specific actions :

* Identifying potential markets/new products
* Identifying new opportunities/aiding investment decisions
* Identifying threats to existing products
* Estimating markets
* Identifying feasible projects for new investment/project selection
* Identifying newer R & D
* Identifying areas for diversification and expansion.

In the following section, a discussion is provided on some specific cases involving applications of TF to corporate planning.

SPECIFIC CASES

Cotton Textile Industry

Cotton is being substituted by man made fibres but still man made fibre/cotton blends are preferred by consumers, mainly because of some specific characteristics of cotton. The only disadvantage of cotton being its poor crease resistance, cotton industry can still remain the leader, if, it can impart crease resistance to cotton fibres. Technological forecasting exercises indicate that the various possible solutions as (a) cotton fibre impregnation; (b) cotton fibres/other

Table 1

Corporate Planning and T. F.

Policy Planning	Strategic Planning	Operational Planning
1. Select the objectives	1. Select the strategy	1. Select the tactics
2. Identify alternatives	2. Visualize the corporate boundaries	2. Identify the sub-systems
3. Determine goal feasibility	3. Evaluate the alternatives	3. Integrate with the corporate and R&D plan
4. Anticipate threats	4. Find the road blocks	4. Initiate market tests and initiate marketing activities
	5. Plan the system	
Examples		
Better automobiles	Development of a newer engine - electric car	Improvement of battery to change its charge discharge cycle
Diversification of an electronic industry	Horizontal and concentric diversification Into application systems	Develop microprocessor based systems
Cement industry expansion	Production process improvements	Newer catalytic processes
	Diversification into consumer items	Production of modular house units, bathrooms etc.
Fertilizer Industry	Improved NPK mixtures Algae + P + K mixtures	Development of Algae application

fibre combinations instead of yarn; (c) cotton fibre reinforced plastics; (d) cotton fibre improvement by genetic changes, and (e) cotton fibre improvement by physical/chemical/irradiation treatment or fibre implantation-exist and detailed assessment of various options has to be undertaken.

While looking at the potential threats to cotton textile technology, monitoring exercises show that some other countries are trying to manufacture non-woven cotton fabrics, i.e., directly from cotton fibres. Many other countries are trying to enter into textile markets and they plan to make Indian textile obsolete. Japan owes its technological skill to the special emphasis on production process technologies rather than product related technologies. This has given them an edge over nations which stress innovations in product related technologies. It is time that India also looks ahead for technology from a longer perspective. In case non-woven cotton textiles are being commercially manufactured abroad there will be a cost shift in their favour and our textile industry will become obsolete. This is, thus, an area where offensive planning is highly imperative.

Electronics

IBM has withdrawn from India. This gives a very ideal opportunity for the Indian Electronics Industry to diversify. Instead of vertical diversification some of those units can go in for horizontal diversification. Proper long range planning backed up by efficient market strategy based on

technological forecasting may be essential to maintain the market control. The possible alternatives are :

* To make specific application systems (documentation systems, traffic control systems, health care systems, process control systems, education systems, automated transportation systems, etc.) A long term demand assessment is very desirable.
* To go in for collaboration with specific application organisations (ISRO, NRSA. IIM, GSI, ICAR, HMT, Fertilizer Corporation of India, HSL, Road Transport Undertakings, Indian Airlines, IIT, etc.) to develop micro-processor based application systems.
* To have better systems for computation like multi-programming, multi-language systems.
* To develop software packages in advance for clients.
* To integrate functions into chips and go in for micro miniaturization and also to go in for newer electronic instruments for energy meters, auto-fare meters, etc.
* To consider changes in printing technology so that newer printing equipments can be designed and manufactured, like laser printing inkjet printing, thermal printing etc.
* To make functional systems specifically for forecasting, inventory control, job allocation, project management, design of structures, analysis of structures, piping design, pressure vessel design, turbine design, market distribution, etc. and
* To initiate a central scientific and technological information dissemination centre on a commercial basis with a view to export orientation. Effort can be made to capture African and South Asian markets.

Detailed technological forecasting and long range planning studies are necessary for this.

Leather Industry

Leather industry in India is facing severe competition from plastics and allied products. Except for shoes and other things, leather is not an exclusive material. If leather industry has to survive the onslaught from plastics sector it has to initiate strategies for cost reduction. An analysis of cost structure in leather industry will reveal that labour charges are the major component of a leather industry. The reduction in labour charges can be made possible in all areas and most critical area being stitching. If there can be an alternative process for leather joining instead of the time consuming sewing, leather industry may fare better. Similarly, leather will deteriorate in the presence of moisture. A coating which can make leather water-proof can revolutionise the demand and competition pattern. Only such functional improvements such as these will help the leather industry to survive in the long run but not the ones based purely on fashions or shapes.

Cement and Asbestos Industry

This group of industries in India has not gone for any horizontal diversification. In the long run, this group of industries has to go in for polymer reinforced concrete products ferrocement products and prefabricated housing products. Though technology is available, design procedures with polymer reinforced products have not been standardised. Similarly, construction of modular units for houses (like bath etc.,) is another venture where technology is available and product is desirable. Apart from these product innovations, a detailed look into the production technology will help in cost reduction. Energy being a major input to cement and asbestos industry, energy saving innovations, design improvements, development of low temperature cement production processes, development of calcination catalysis etc., may be considered as possible options.

Railways

Though Indian Railway has prepared a corporate plan, it has not been made after detailed and dynamic computer simulation exercises. Changes in fuel prices, other competitive transportation modes, technologies, costs of transportation options, maintenance options,

replacement options, operating options, investment modes, industrial demand patterns, inter-state freight movements etc., can change rail traffic considerably and only simulation models will be of help in such situations. Technology forecasting based long range planning of operations will certainly be more effective for a sector like Railways. This is more so because many technology breakthroughs are occurring in the area of transportation.

Service Sector

Services has been another major sector in India where an integrated corporate planning is virtually absent. Activities like banking, insurance, water supplies, electricity generation and distribution, posts and telegraphs, general administration, public distribution and civil supplies, urban administration, etc., are continuously on the increase No systematic policy analysis and corporate planning efforts have been undertaken in this area. Even managerial inputs into these areas have been marginal. Proper integration of these services, planned design of the proper systems, training professionals for these services and allocating finances for these sectors require detailed long range forecasting exercises.

Watch Industry

Recently, a number of manufacturers have migrated to this product line, the major one being HMT. Some of these organisations have gone into this area without perspective planning. Electronic watches have entered the market in India mainly through foreign collaborators. Under these conditions, it would be appropriate if companies like HMT, could analyse the long term changes in horology which has been subjected to vast changes in a short time and the innovations in electronics industry are being horizontally transferred to this area. Never technologies and breakthrouhs in horological area can make vast amounts of public investments non-productive. Even watch manufacturers should diversify into other measuring technique-areas with their precision. Japan's entering into many production areas is mainly due to its intense development work in production process related technologies or in functional technologies rather than in products.

Table 2

TF and its Applications

Industry / Level	Technology fast changing (electronics)	A stable Technology industry (Steel)	A Service organisation (Defence, P&T)	Intense competition (Drugs)
Top Management Level	An early warning system. Long term R&D Plan.	Identify long term threats defensive plans.	Integrate long term options and short term plans.	Long term product options. Long range corporate plans.
Middle Management Level	New product options Offensive plans.	New process alternatives. Long term market plans.	Modernization planning obsolescence avoidance.	Corporate contingency plans. New Product threats.
Junior Management Level	Cost reduction value Engineering. Generation of new ideas. Product development	Short term product changes. Generation of new application areas. Process R&D project initiation.	Roducing obsolescence. Generating new procedure or process alternatives.	New drug formulations. Toxicological modifications.

Steel Industry

It is time that Steel Industry planners of India looked into the total industry sector. Though the industry is expanding in size the companies have not diversified into other functional sectors. Steel Industry has witnessed minimum structural changes. This is perceptible from the increasing iron ore exports from India. Though a number of small scale sector steel plants have mushroomed, an integrated look is absent. Some major long-range options for the survival of the industry are :

* Diversifying the large HSL units—horizontal
* Initiating newer product units
* Increasing R&D in production process related technologies
* Going into construction related areas and prefab products
* Decreasing raw material exports to finished product export
* Development of hydrogen based iron ore reduction etc.

REFERENCES

1. Rohatgi, P. K. Rohatgi K. and Bowonder, B. *Technological Forecasting*, Tata Mcgraw Hill, New Delhi, 1979.
2. Bowonder, B. Technological Forecasting and Research Management, *Chemical Age of India*, Vol. 28, 39-46, Annual 1978.
3. Rohatgi, P. K. Vyas, B. J. and Bowonder, B. Technological Forecasting for Foundry Industry, *Journal of Scientific and Industrial Research*, Vol. 37(1), 1, 1978.
4. Bowonder, B. and Rohatgi, P. K. Future of Steel Technology in India, *Journal of Scientific and Industrial Research*, 36(8), 355, 1977.
5. Bowonder, B. Technological Forecasting in Indian Companies, to be published.
6. Bowonder, B. Long Range Forecasting and the third world, submitted to Futures.
7. Jones, H. & Twiss, B. C. *Forecasting Technology for Planning Decisions*, Mackmillan, London, 1978.
8. Martino, J. P. *Technological Forecasting for Decision Makers.* American Elsevier, New York, 1972.
9. Shoeman, M. E. S. and Bright, J. R *A Practical Guide to Technological Forecasting*, Prentice Hall, New Jersey, 1973.
10. Linstone, H. A. and Sahal, D. *Technoloigcal Substitutions*, American Elsevier, New York, 1978.

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Executive Leadership

A. N. SAXENA
National Productivity Council, New Delhi

From the standpoint of society, the world may be divided into leaders and followers. Every profession has its leaders. It is therefore difficult, if not impossible, to separate the element of leadership and the element of personal gain or advantage to the individual, without which any leadership would lose its value.

It is in military system only, that men sacrifice their lives for a call, since they are willing to suffer and die for the right or the prevention of a wrong. In this form it could be stated that we realize leadership in its most exalted sense.

Be an Example to your men. An executive can be a power for good or a power for evil.....He must endeavour to make light of his troubles, belittle his trials & help build up an ESPIRIT DE CORPS within his organization whose value in time of stress is immense.

In the military system men have to follow because the driving power behind them is not enthusiasm but discipline. They go with doubt and trembling that prompts the unspoken question, "What will he do next ?" Such men obey the letter of their orders but no more of devotion to their commander, of exalted enthusiasm which scorns personal risk, of self-sacrifice to ensure personal safety. Their legs carry them forward because their brain and their training tells them they must go. Their spirit does not go with them and so they are not creative. They are only doers. It therefore cannot become the basic operative in other systems including the industrial leadership.

Great results are not achieved by cold, passive, unresponsive actions. They don't go very far and they stop as soon as they can. Leadership not only demands but receives the willing, unhesitating, unfaltering obedience and loyalty of other men; and a devotion that will cause them when the time comes to follow.

A question can still be asked unhesitatingly : of what, then, does leadership consist of ? What must we do to become a leader ? What are the attributes of leadership, and how can we cultivate them?"

Leadership consists of a number of qualities. Among these most important may be listed Self-Confidence, Moral Ascendency, Self-Sacrifice, Paternalism, Fairness, Initiative, Decision, Dignity and Courage.

Self-Confidence results, first from exact knowledge; secondly the ability to impart that knowledge; and thirdly the feeling of superiority over others that naturally follows. To lead, one must know that one can bluff his men only for some time, and not for all the time. Men will not have confidence in the superior unless he knows his business, and he must know it from the ground up.

There is no substitute for accurate knowledge; one should be so well informed that men will hunt him up to ask questions; even his colleague may say to one another, "Ask him he knows".

Not only should an executive know thoroughly the duties of his own job, but he should study those of the two grades next above him. From this a two-fold benefit may accrue. He prepares himself for duties which may fall to his lot; he further gains broader view point which enables him to appreciate the necessity for the issuance of orders and join more intelligently in their execution.

Another element in gaining moral ascendency lies in the possession of enough physical vitality and endurance to withstand the hardships to which a person in leadership position and his men are subjected, and it is the dauntless spirit that enables them not only to accept the hardships cheerfully but to minimize their magnitude.

One must endeavour to make light of his troubles, belittle his trials and help vitally to build up within his organisation an espirit whose value in time of stress cannot be measured.

Moral Force is the third element in gaining moral ascendency. To exert moral force one must live clear; one must have sufficient brain power to see the right and the will to do 'right'.

Be an example to your men.

An executive can be a power for good or a power for evil. Don't preach to them—things that will be worse than useless. Live the kind of life you would have them lead, and you will be surprised to see the numbers that will follow you.

When I say that paternalism is essential to leadership I use the term in its broader sense. I do not refer to that form of paternalism which robs men of initiative, self-reliance and self-respect. I refer to the paternalism that manifests itself in a watchful manner for the comfort and welfare of those working with you.

> *And by doing all these things you are breathing life into what would be otherwise a mere machine. You are creating a soul in your organization that will make the mass respond to you as though it were one man. And that is espirit.*

Study your men as carefully as a surgeon studies a difficult case. And when you are sure of your diagnosis apply the remedy. And remember that you apply the remedy to effect a cure, not merely to see the victim squirm. It may be necessary to cut deep, but when you are satisfied as to your diagnosis don't be diverted from your purpose by any false sympathy for the patient.

> *Consideration, courtesy and respect towards man are not incompatible with discipline. They are part of our discipline. Without initiative and decision no man can expect to lead.*
>
> *Any responsible order in an emergency is better than no order. The situation is there. Note it. It is better to do something and do the wrong thing than to hesitate, hunt around for the right to do and wind up by doing nothing at all. And, having decided on a line of action, stick to it. Don't vacillate. Men have no confidence in a person who doesn't know his own mind Every time you change your orders without obvious reason you weaken your authority and impair the confidence of your men. Have the moral courage to stand by your order and see it through.*

Moral courage further demands that you assume the responsibility for your own acts. If your subordinates have loyally carried out your orders and the movement you directed is a failure the failure is yours not theirs. Yours

would have been the honour had it been successful. Take the blame if it results in disaster. Don't try to shift it to a subordinate and make him the scape-goat. That is a cowardly act. Furthermore you will need moral courage to determine the fate of those under you. You will frequently be called upon for recommendations for promotion of officers and you have to be candid and honest.

> *It is taken for granted that you have physical courage. I must emphasize how necessary that is. Courage is more than bravery. Bravery is fearlessness—the absence of fear.*

And, lastly, if you aspire to leadership, I would urge you to study men.

Get under their skins and find out what is inside. Some men are quite different from what they appear to be on the surface. Determine the working of their mind.

In the aviation industry with the introduction of jet mechanism as against propelling system, technology has brought about astounding achievements both in terms of performance and speed. The Jet mechanism is based on 'Trust' and this technology has brought about fantastic achievements. The same mechanism when applied to human systems and leadership qualities can bring about better results. Finally I would like to summarise the leadership qualities can be briefly defined in one word IKADRA which calls for six instrumentalities—Imagination, Knowledge, Ability, Determination, Resourcefulness and Authority.

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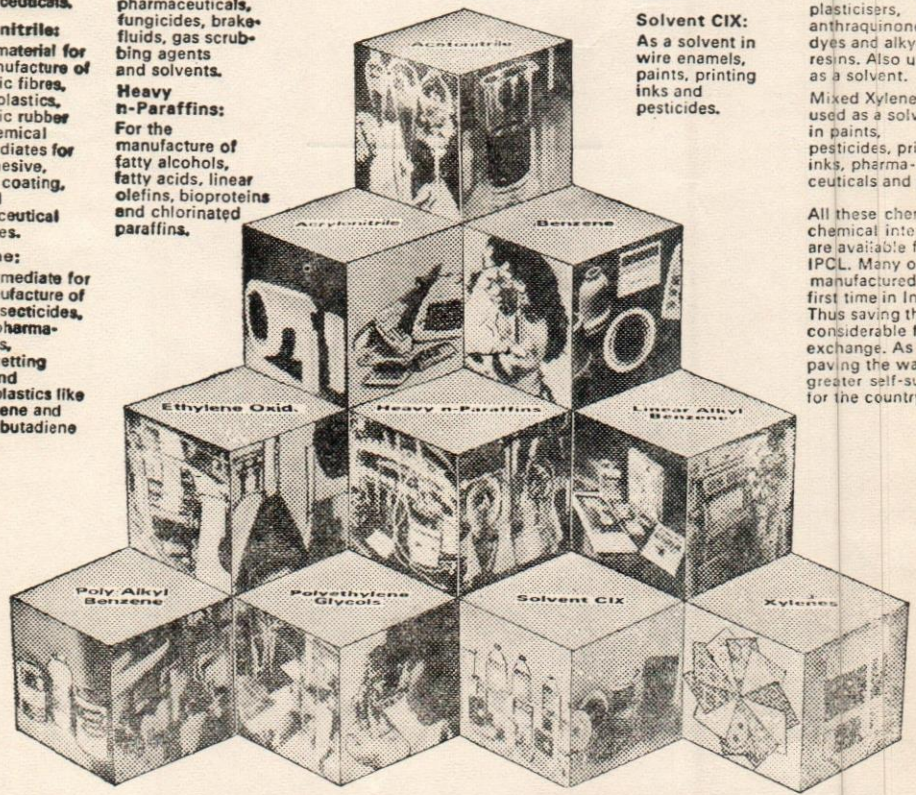

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EXECUTIVE READINGS

Management by Objectives : A Japanese Experience

By Takanobu Hongo

Published by Asian Productivity Organization, Tokyo

**Reviewed by Dr. M. Yoga
National Productivity Council,
New Delhi**

It is stated that the book is based on the practical application of the concept of management by objectives for over ten years in Toshiba Electric Company. MBO being the creation of Western Industrial culture needed to be changed to make it appropriate and effective in a Japanese setting. Essentially, these changes meant greater flexibility of the system and comprehensive coverage of activities. Special features of the work environment which demanded these changes have been identified. A presentation describing how a foreign concept/system was integrated into an Eastern work culture, is of great interest to managers in India. Though the book is based on long experience in one company, the style of writing is simple without too many technical details. This publication is meant for practising managers rather than specialist staff.

MBO is viewed in relation to other systems such as OD and QC programmes as well as profit control and personnel evaluation systems. The basic conclusion highlighted is that MBO represents a total system which integrates all others such as the ones mentioned above, as sub-systems. Such a conceptual clarification and marking of jurisdiction of different systems goes a long way in making MBO more effective. Further four structures—structure of organisation, structure of work, structure of manpower development and structure of communication, constitute the governing factors for any MBO system. All these need to be critically examined to identify aspects which require to be modified to facilitate MBO process. Some of the basic preparations for MBO are identified. These are conversion of flock organisation to team organization, small group formation through change in work process, reducing levels of organization and reshaping one dimensional relationship into two dimensional relationships.

A couple of chapters focus on designing an MBO system that takes into consideration special features of work environment such as the composition of work groups, nature of objectives of various groups, criteria for evaluation of progress achieved, whether the implementation unit is an individual or a group and the performance schedule. Such a dovetailing exercise leads to easy acceptance of the system and its effective implementation. It would have been very useful if more detailed information had been incorporated, as to how these modifications were identified and about the process of introducing MBO system to various groups in the organization.

Detailed material is provided regarding setting up of appropriate goals and the procedures for implementing MBO are stated in sequence. However, there is not enough information regarding the prob-

lems encountered, how these problems were overcome and whether some features of the MBO system had to be toned down in order to overcome resistance. More detailed description and discussion, particularly regarding the initial problems during implementation would have been of great interest and value to managers.

A document which is of interest in the context of monitoring results and evaluation is 'goal administration card'. It is a simple card, on the basis of which monitoring is done and the people concerned are kept in touch with the progress achieved. Chapter seven details the steps involved for effective implementation of the three stages of the MBO process goal setting, goal accomplishment and performance evaluation.

The style of writing is simple and clear. The presentation of the tables could be better. Addition of suitable bibliography would be a welcome feature. Reference material at the end of the book is useful. On the whole, a well written book and a valuable addition to management literature. □

Decision Styles and Organisational Effectiveness

By B. L. Maheswari

Vikas Publishing Home (Pvt) Ltd. New Delhi

Reviewed by B. L. Lalvani New Delhi.

The author has undertaken a sample study of Indian business with a view to finding out the relationship between decision styles and organisational effectiveness. The sample represents a diversity of business organisations in India varying in size, strategies, technology, ownership structures and in terms of historical traditions, experiences and specific external environment. The sample embraces a wide spectrum of large scale business organisations in both the private and public sectors.

It is found that organisations in both the above sectors have been slow in adopting diversification strategies and divisional structures. There are, however, differences between the two with respect to age, technology, size and environment. The private sector companies have achieved higher output and profit in proportion to resources employed. Because of less efficient use of resources, public companies have more inputs in terms of human and financial resources. Public sector companies operate in a more favourable environment and are less bureaucratic than those in the private sector, contrary to prevailing belief. Their accent is on commercial functions in private companies, while there is more emphasis on production functions in the public sector judging from the larger number of managers employed in performing these functions. In general, Indian organisations are essentially production-oriented. Three-fourth of the managers are middle aged.

Indian organisations are not characterised by an extreme degree of either bureaucratic or entrepreneurial management style but tend to be more bureaucratic than entrepreneurial. This results in management by crisis and muddling through in emergencies. This applies to both private and public organisations contrary to the belief that private sector displays more entrepreneurial drive.

Indian organisations like their counterparts in Europe and America do not practice joint or participative decision making on important matters. Public sector managers have a higher preference for this type of decision. This could be due to trade off between opportunities for participation and material gains. Managers below 36 and above 46 have lower preference for participation and managers in commercial functions have preference for higher participation than in other sectors of activity. On the whole, public sector top management is not perceived to be consistent, resulting in lowering of respect for its integrity and acceptance of its decisions.

Communication barriers between different hierarchical levels are overcome by the practice of oral communication of decisions at meetings between subordinates and superiors. The private sector commands better acceptance of their organisational goals from their members than organisations in the public sector.

The conclusions of the study are that firms characterized as "giant under fire" "lucky innovator" "dominant firms" have prospered on account of favourable environment (government protection, etc)

including marketing environment despite the fact that they were weak in systems capability and employee morale. Unsuccessful organisations however classified as "headless giant" or "swimming up stream" in the absence of favourable environment, owed their failure to lack of systems capability and low morale. Depending on a favourable environment is like building on quicksand. In the long run the systems and people variables are critical for continued organisational effectiveness since the external environment can be controlled only to a limited extent. Hence the importance of building internal strengths represented by strong systems, competent and enthusiastic workers and a high degree of adaptibility to change in environment and product technology. But organisation effectiveness is not enough for ensuring growth. For growth, a favourable environment is a must coupled with authoritative and entrepreneurial decision making which is characterised by a readiness to take risks, innovation, non-conformity to rules and adaptation to changing environment, as distinguished from bureaucratic decision-making marked by rigid adherence to rules, lack of anticipation and aversion to taking risks.

According to the author there is ample literature on the connection between participative culture and organisation effectiveness (OE). The relationship between organisations effectiveness and entrepreneurial style of decision making which the writer has tried to establish, has however, received scant attention from other writers. But, says the author, big business still swears by entrepreneurial style of decision-making and participative culture is not widely prevalent as is generally believed. However, participative styles and entrepreneurial styles are mutually supportive in contrast to bureaucratic style. Further research into the relationship between the two is recommended for evolving better decision styles for making organisations more effective in satisfying the needs of society and stock holders. □

Development of Industrially Backward Areas—The Indian Style

Dr. S. N. Bhattacharya

Published by Metropolitan Book Company Pvt. Ltd., New Delhi 1981.

Reviewed by Navin Chandra Joshi, Moti Lal Nehru College, University of Delhi, Delhi

After revision of the Industrial Policy Resolution in 1956, the Government of India and the Planning Commission began to consider ways and means to attract industries to relatively backward areas. It was realised that in order to reduce regional disparities and ensure decentralisation of small-scale industries in backward areas, it was necessary to identify the criteria for selecting backward areas, for development programmes. At the same time it was felt that there can be no single strategy for development of all backward areas of the country.

One significant strategy could be the setting up of local resource-based industries. It is well-known that the most important problem of backward areas is their overpopulation as also unemployment of the people living there. To overcome this problem and to stop the migration from rural to urban and semi-urban areas, projects using labour-intensive techniques, local resource-based and appropriate demand-based industries need to be encouraged. Necessary and adequate infrastructure facilities should also be provided for the development of such industries.

In this book of nine chapters and ten appendices the author takes us through the several ramifications of backward area development. The introductory chapter is however, presented haphazardly containing as it does disjointed themes wherein the author too quickly shifts between thoughts, topics, policies and prescriptions. On the issue of rural industrialisation it is observed that maximum productive employment of local resources, revival and development of traditional industries and skills, establishment of new units and integration of agricultural and industrial development should be the primary aim.

While the subject of integrated rural development has been adequately discussed with the help of a case study, the author gives a somewhat perfunctory treatment to the growth centre approach. His handling of the subject leaves much to be desired. The growth centres need to be selected on the basis of their linkage bet-

ween rural and urban economies through an appropriate infrastructural and institutional network. In such growth centres, appropriate projects could be taken up depending on the availability of local resources. Besides, in each backward area sites should be selected for industrial estates wherein all facilities are provided to entrepreneurs at concessional rates. If possible, the estates should be located in the proximity of district headquarters where workers' housing, medical, educational and other facilities are available.

The development of infrastructure is the key to the success of such programmes. It will ensure the proper provision for railway, road and communication facilities in all backward areas. Besides, there should also be an adequate number of warehouses and marketing centres for the produce of agriculture and industry. Lack of these will defeat the very process of giving a boost to development in backward areas. It would be desirable to develop the main focal points which possess minimum infrastructure facilities and extend them to other backward areas on a priority basis.

The role of financial institutions and entrepreneurship has also been discussed in the book. The author believes that the existing incentives and subsidies have a tendency to encourage capital-intensive industries in some cases and as such, they do not have a beneficial impact on the development of backward areas. He suggests that multi-dimensional programmes should be taken up in backward areas. "Our efforts for developing entrepreneurship in backward areas are likely to bear quick results if care is taken to identify inputs and put them into action in an integrated manner and at the proper time." It is true that financial incentives alone are not adequate to take the industries to backward areas. Some kind of a package programme for self-employment of qualified young engineers and technicians should be undertaken. For this, programmes of training for motivation, information, consultancy and supporting services are essential. Indeed, with a clear perception of what needs to be done to encourage entrepreneurship in backward areas, half the battle may already have been won. □

Management of Absenteeism

By S. K. Bhatia

Published by Asian Publication Services, New Delhi-24.

Reviewed by C. D. Nandwani
Bharat Heavy Electricals Limited, Bhopal

With the development of a vast industrial network in the country, certain ancillary problems have come to the fore. Absenteeism is one of the major human problems in industry which results in loss of production, increased labour cost and reduced efficiency of operations. This problem is multifaceted and needs to be split in smaller parts to allow thread-bare analysis of the factors involved before suggesting any remedies.

In his recent book "Management of Absenteeism" Shri Bhatia has made an attempt to delineate the problem of absenteeism in industry. The tools used to analyse the problem, the empiricals suggested as remedies, make the book a worthwhile addition to the literature on Management studies.

The book covers several facets of the problem from concept and causes to methodology for analysis and remedial measures. It is a practical guide to managing absenteeism at the micro and macro levels using an integrated approach.

The author has analysed the problem of absenteeism using three empirical studies, using three different methodologies, namely (i) "condition-centred," (ii) "person centred", and (iii) identification of other factors responsible for high absenteeism Through these studies he answers five basic questions: What is the quantum of absenteeism ? What is its pattern ? Where is absence occuring ? How many individuals are involved ? and, What conditions or factors cause absenteeism ? He further diagnoses the nature of inplant, personal and external factors associated with absenteeism and highlights their impact.

A separate section reviews the research findings on absenteeism in India and abroad. It is obvious that much more research needs to be

done before effective techniques to control absenteeism can be developed.

Four chapters deal with the aspect of remedial measures. One chapter is exclusively devoted to tackling absence due to indicipline. "Specific cures" and "alleviative cures" are discussed with their merits and demerits. In tackling absenteeism in an organisation, the author emphasizes an action oriented approach in four steps—(a) devising strategy for control and prevention of absenteeism, (b) creating awareness and involvement of supervisory and executive personnel, (c) spelling out unit target for reduction of absenteeism on yearly basis, (d) formulation of an action plan for implementation.

Basic research studies, have indicated that a small number of 5 to 10% of habitual absentees normally inflate the rate of absence. By tackling habitual absentees alone, the rate of absence can be brought down by about 4 to 5%. The habitual absenteeism is primarily due to 'personal factors' and as such a 'person centred approach' is called for to rehabilitate the chronic absentees. The stress is on the constructive approach through counselling in tackling the habitual absentees. To bring home this point, the author includes a study relating to effectiveness of counselling on habitual absentees. However it seems likely that a judicious mixture of counselling and disciplinary action may prove more effective than counselling alone.

Bhatia's book is a significant contribution to the field of management education and personnel research. He has dealt with the problem comprehensively with a practical and positive approach. The style of the book is simple, readable and result oriented. Managers, executives, supervisors and students in the line will find this book interesting The ideas elaborated in the book can be put to good use for improving productivity through better management of absenteeism. □

Preparing an Organisation Manual

J.C. Morrell, British Institute of Management Foundation, Management House, Parker Street, London

Reviewed by Kewal Soeny.

It is not a common practice in India to produce organisational manuals in spite of the great need for them. The more usual procedure is to apply the rule of thumb, follow practice or use managerial discretion when the need to refer to a manual arises. The government is probably the largest producer of manuals of its own kind with rules and regulations to be followed strictly, though people spend much time trying to find loopholes in them. Then there are those who appreciate the need but do not have the resources or knowledge to produce a comprehensive manual which would be relevant for at least some time. Both industrial and non-industrial organisations fall in one of these categories.

But it is interesting and heartening (?) to note the author's observation that in Britain too, although so many organisations do produce manuals, there is little formal instruction on the subject and a reluctance between organisations to share skills and experience, perhaps because so few of their manuals are effective.

A manual is a collection of notes issues to employees or members, containing information and instruction pertinent to the work of the organisation. It may be used for training or reference, and may either consist of a fully comprehensive set of notes covering every facet of the organisation or be limited to a particular topic—perhaps as one of a series. Generally, manuals are loose-leaf binders, and the text is referenced and indexed to enable the contents to be kept up to date by the issue of replacement sheets.

This is a very well-written book, clear, precise and methodical in its approach. The author has listed several situations where a manual would serve as a valuable and reliable guide to "doing the right thing." Thus, a manual is helpful in communicating accurate information about procedures and standards in defining policies and specifying responsibilities, and in improving the effectiveness of organisational systems. Reliance upon an existing manual can be dangerous, though, if systems have not been enforced, as people have a habit of devising their own ways of doing things and developing unnecessary subsystems.

The book opens with a chapter of the use of the manuals followed by its purpose, scope and responsibility, types of manuals, production, presentation, reference and indexing, updating and making a start. The reading list at the end which forms the last chapter, however, does not give many references which also indicates the paucity of material on the subject.

While each organisation will have to have a manual which answers the kind of questions its employees are going to face in their day-to-day work, the author has listed hundreds of possible areas which need to be included in different kinds of manuals like organisation manual, personnel, office administration, financial and accounting, sales, purchasing and so on. Another notable point is the influence of O & M on the author which indeed should be a part of the training of an adviser in this area.

An excellent job done of advice on manual writing. Even Bharat Heavy Electricals which did an admirable job of producing a very worth-while manual and won great applause would be able to learn a few things from this book. □

The Creation of Wealth

By R.M Lala

IBH Publishing Company, 1981,

Reviewed by V.S. Mahajan

The book under review relates to the success story of Tatas. Over a hundred years ago Jamsetji Tata ventured into areas of modern industry against heavy odds of capital, technology, severe competition from imported goods and, above all, un-cooperative attitude of the then Indian government. It was owing to the shrewedness, tenacity and hard efforts of Jamsetji that the industrial map of the country gradually underwent a structural transformation. His earlier interest was in textiles and he had in 1877 established successfully a textile mill in Nagpur and in 1886 had bought a sick textile mill in Bombay and turned it into a healthy unit within a few years. Jamsetji enjoyed such a high reputation among the people that he could have raised any amount of capital for starting more textile units. But his aim was not profit-making alone. He was even more interested in laying the strong foundations of the Indian economy and here he realised that without the growth of basic industry, cheap electric power, scientific research and trained technicians this dream could not be realised. Thus in the later years of his life he struggled incessantly to fulfil this dream.

Starting from 1882 Jamsetji had begun his ambitious struggle to give India the latest steel plant—not many of the present developed countries had modern steel plants at that time. To fulfil this ambition Jamsetji struggled hard against many odds for over 25 years. Initially he had to find a suitable site for the location of the steel plant where there were plentiful supplies of raw materials as well as of water. However, finding of such a site was an arduous job in those days of poor geological surveys and extremely trying travel conditions. But Jamsetji was undaunted. He travelled extensively across the vast area of this country in the company of experts looking for an appropriate site. He also travelled frequently to Western countries to study steel technology and minerals to hire the services of the best experts available. Obviously under these conditions it was years before the present site, Jamshedpur, was finally selected.

Unable to raise capital for the steel plant from the British money market as was originally planned, Tatas ultimately decided to try the Indian market. It was heartening to find that within three weeks the needed capital was raised from 8000 investors. This was the first time that Indian hidden wealth came to the surface for such a giant venture. A total capital of Rs. 2.32 crores was raised. It shows that raising of industrial capital was never a problem in this country, provided it was raised by a sound business house in whom the investors had full confidence and faith. And Tatas did enjoy such faith in abundance. However, Jamsetji did not live to see the plant. He died in 1904 in Germany. In his last days he urged his son, Dorab, and close members of his family to carry forward the work he had started. "If you cannot make it great, at least preserve it. Do not let things slide. Go on doing my work and increasing it, but, if you cannot, do not lose faith in what we have done." In fact, subsequent

experience showed that the steel plant for which Jamsetji had worked so hard and which he had brought to the final stage was not only maintained but was considerably expanded.

Similarly Jamsetji's dream for cheap power, produced with the aid of modern big-sized plants, was realised after his death. The giant Tata Hydro-Electric Power Supply Co. was established in 1910, followed by the Andhra Valley Power Co. in 1916 and the Tata Power Co. In 1919. It is interesting to find that today the entire distribution of electricity for greater Bombay and Bombay city is done by the Tata Electric System from its load despatch centre at Trombay.

Jamsetji, was also keen that India have a science university, where students could get the highest education in different fields of science and research could be carried out to benefit the Indian economy. To fulfil this dream he " in 1898 set aside 14 of his buildings and four landed properties in Bombay for an endowment to establish a university of science". It was not untill 1911, however, that the Institute of Science was opened and this institute was subsequently to occupy a place of high pride in learning and research in various sciences.

Jamsetji was thus a veritable character. Not only was he interested in building up material capital, he was equally interested in building up human capital. He was keenly interested in labour welfare, training and education. Long before labour was protected by law he had introduced a package of labour welfare programmes in factories controlled by him. While today we deplore the lack of good hotel facilities for foreign tourists in particular, it was Jamsetji who had 80 years ago measured this, problem and had created Taj Hotel which for years was considered the best hotel in the Middle-East, South and South-East Asian countries. The hotel was opened in 1903 during Jamsetji's life time.

Subsequently, industrial complexes managed by Tatas have multiplied in number and are to be found in areas which demand a high degree of investment and technology as well as skilful management. Thus Tatas have succeeded in creating a large industrial wealth for the country, which runs into several crores of rupees. They have also created both direct and indirect employment avenues for a very large section of the Indian population. Their continuing interest in social welfare, educational programmes, medical facilities, management education, sports, various research programmes and the like makes impressive reading. And much of this is owing to the pioneering efforts of Jamsetji and the spirit of dedication of those on whom the burden of managing this vast industrial empire has fallen.

The book is very well produced, written in an elegant style and reasonably priced. It should be a source of great inspiration to budding entrepreneurs, and students of industrial economics would read it with interest. It should also be an eye opener to our administrators in making them realise that given the appropriate direction and encouragement the private sector in India is capable of producing a large wealth for the country and could also create large employment opportunities. □

Agricultural Growth in Japan, Taiwan, Korea and the Philippines

Edited by Yujiro Hayami, Vernon W. Ruttan and Herman M. Southworth.

Asian Productivity Organisation (1979) East West Center Book.

Reviewed by N. K. Jain
New Delhi

Eleven papers contained in this volume were initially presented in a conference at the East West Center, Honolulu February 5—9, 1973. The conference was sponsored by the Food Institute of the East West Center, the Economic Development Center of the University of Minnesota and the Agricultural Development Council.

The book consolidates in one volume the available quantitative evidence on long term growth of agricultural output, inputs and productivity for the three East Asia countries, Japan, Korea and Taiwan and for the Philippines. The organizers of the conference and the Asian Productivity Organisation can legitimately claim that, for the first time, comparative data on agricultural inputs, outputs and productivity have been brought together for a group of recently developed and developing countries. The information in the

volume contains is indispensable for both analysis of the quantitative changes associated with modernisation of the agricultural sector and formulation of national development policies and plans. The discussions on the methods used to construct the output, input and productivity series in each country would be useful to economists and other professionals in other developing countries who seek to extend social accounting systems to include productivity accounting for the agricultural sector.

The book has four parts Part I, contributed by Y. Hayami and V. W. Ruttan provides a well written summary of the experiences of the four countries in agricultural growth. The authors first identify the contribution of growth accounting to development theory and practice and indicate the significance of the East Asian experience. They then compare the growth patterns revealed by the four country studies and suggest implications regarding future agricultural development in South Asia.

Part II contains four detailed country-wise studies on agricultural growth; Japan by S. Yamada and Y. Hayami, Taiwan by T. Lee and Y. Chen, Korea by S. H. Ban and Philippines by C. C. David and R. Barker. In addition to the detailed analysis of agricultural growth in these countries, the papers are rich in discussions on the methods, sources and data used for each country. Part II, infact, constitutes the core of this book. The primary aim in each country study has been to measure changes in agricultural output, input and productivity over as long a period as that for which usable data on the country's agriculture could be obtained. As a basis for this, annual data on outputs and inputs was first compiled and index numbers were constructed for them. Indexes of productivity were then calculated as ratios of input and output indexes.

Part III has been devoted to critical reviews of the methods of measurements used in the four country studies of Part II. The reviewers are: A.M. Tang on "Output Measurement: Data and Methods"; H. Kaneda, on "Measurement of Labour Inputs : Data and Methods"; Tara Shukla, on "Land and Capital Inputs : Data and Measurement"; and D. D. Durost, on "Current Inputs : Data and Measurement". As the titles of these reviews suggest, the authors have dealt with a wide range of empirical and conceptual issues relating to growth accounting of agriculture. Indeed, it is difficult to provide even a synopsis of these critiques in this brief review

In part IV, two authors present their treatment of the perspectives on productivity measurement and agricultural development. J. W Kendrick's "A Perspective on Partial and Total Productivity Measurement" offers a brief, but excellent treatise on the conceptual issues and methodological problems in productivity measurement. K. Ohkawa's "Implications for Agricultural Development" concentrates on the implications of measures of total as well as partial productivity growth.

The book is certainly a unique contribution to growth accounting and productivity analysis. Its relevance need hardly be emphasised in the context of the emerging agricultural sector in South Asia. As a sequel to this conference and the book, it may be considered whether similar work could be undertaken in the case of South Asian economics like India, Pakistan, Bangladesh, Nepal, Sri Lanka and Bhutan. □

Human Relations & Organizational Behaviour

By R. S. Dwivedi

Oxford & IBH Publishing Company, New Delhi (1979).

Review based on the reviews by Vijaya Rao, National Productivity Council, Madras, and Rahul Bhatnagar. Institute of Productivity & Management, Ghaziabad.

The major problems facing modern organizations are primarily human, not technical in nature. In India, especially, it is the human resource which ultimately determines the productivity and profitability of an organization. However, traditional human relations management has focused on somewhat simplistic assumptions and solutions which have been found to be inadequate. Consequently there has been a shift in emphasis to an understanding, rather than an evaluating, approach to human behaviour in organisations. The human being is assumed to be extremely complex and there are no simple solutions.

The book under review

attempts to provide a conceptual framework for the study and understanding of human relations and organizational behaviour. Essentially, it is a synthesized anthology of the eminent theoretical literature in the field. The influence of writers like Kolasa, Blum and Bitchell is quite apparent. The author has presented his material in nine chapters and has used the tenth to discuss a few case problems illustrative of the principles detailed earlier.

The two major variables of organizational behaviour examined in the book are the formal organization and the human being. The formal organization system consists of structure, processes and technology. The author has devoted a chapter to classical, non-classical and modern organisation structures using the Atomic Energy Commission of India as an illustration. This is followed by a discussion of the informal organization and the interaction of technology with human factors. The major organizational process elaborated by the author is communication with specific reference to communication problems in the Indian context.

The treatment given to "human system" by the author is rather perfunctory in view of the stated scope of the book. Preceeding the discussion of the organization and the human being are two chapters dealing with the historical development of the behavioural approach, and a review of the various theoretical approaches to organizational behaviour. The author has made a notable attempt to include comparitively recent research to provide the reader with a sound theoretical perspective. The penultimate chapter deals with organizational change and development.

The book seems to be intended primarily for students of management. A noteworthy feature has been the relevance of case material and illustration to the Indian context. One would have wished that more care had been taken with the layout and with the rectification of typographical errors. □

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Productivity
1981, XXII, 1, 63-70

Economic Performance of Small Scale and Ancillary Units

K. R. SHALIG RAM
MADRAS

It would have been socially preferable if the expansion of Indian industry had been attained by the coordinated growth of small scale and large scale industry . . . . This philosophy is at the heart of the concept of ancillary relationship. The study found that the mean economic performance of ancillary units was no different from that of small units indicating that there was no net advantage from ancillary relationship as prevailing in India.

Resource-constrained developing nations, have often resorted to promoting small scale industry. There is a belief, that a capital scarce economy would substantially benefit from small scale industry, which could be a device for effectively mobilising scattered resources of capital and labour (likely to be otherwise unutilised) to generate immediate large-scale employment per unit of capital, and consequently ensuring geographic dispersal of industry, with an equitable distribution of national income and wealth.

The origin of the small industry movement in India is traced to the Industrial Policy Resolution of the Government. The following Industrial Policy objectives are relevant :

1. To encourage and protect small industry;
2. To prevent undue concentration of economic power.

There was an obvious departure from these norms, with the initial emphasis in Indian economic planning being on developing heavy industry. The declared rationale was that this was necessary to create the infrastructure for national self-sufficiency. Development of small industry was undertaken at a slower pace. This is indicated by the quantum of funds allocated for promoting small industry over the various Plan periods (Table 1). Possibly, this was a consequence of independent interpretation of the first of the two objectives.

The two objectives taken together, imply something different, namely, that it would have

Table 1

Government Outlays for Small Scale Industry

(Rs. Millions)

	I Plan	II Plan	III Plan	IV Plan (Reappraised)	V Plan Draft Plan
Outlay on Small Industry	51.6*	560*	886.5*	1219.8**	2872.3**

Source : P.M. Bhandari, *A Handbook of Small Scale Industries* (Calcutta : The Peerless Publishers, 1975), p. 49

Symbols : * Actual expenditure
** Outlays

been socially preferable, if the expansion of Indian industry had been attained by the *coordinated growth* of small scale industry and large scale industry, rather than by the disproportionate growth of large industry alone. This philosophy is at the heart of the concept of *ancillary relationship*, which is essentially the forward linkage of small firms (*ancillary units*) typically with a large firm *(master unit)*. The former "*collaborate*" by supplying *intermediate goods* (components, sub-assemblies, *etc.*) to the latter. In contrast, *small scale units* typically manufacture *end-products* and "*compete*" with large firms. If ancillary relationship were sustained during the growth of large industry, this would ensure simultaneous growth and modernisation of small industry.

This had indeed been the experience of some industrially-advanced economies, notably Japan. In Japan, most of the small firms functioned as ancillaries to large firms and the share of ancillaries in the total industrial output was about 30 per cent. According to Verma (Vakil, 1973), Japan had achieved a 30 to 40 per cent reduction in the overall cost due to the practice of sub-contracting.

The general state of small industry in India has always been somewhat obscure, partly because no law requires that it should publish its facts and figures. The Census of Small-scale Industries (1976), revealed that the number of small scale units in the country had risen from 140,000 in 1971-72 to 550,000 in 1975-76. The official definitions for registration of an ancillary unit and small scale unit, imply that both could produce a mix of intermediate goods and end-products [guidelines for Industries 1975-76, p. 17]. As this mix varies, from firm to firm and over time, reliable data on the aggregate output of the ancillary industry are not available. One estimate is that the ancillary industry produces barely 1/2 percent of the total industrial output, as against 30 percent in Japan [*The Economic Times*, Bombay, Oct. 19, 1976]. Thus, it is apparent that the buyer-seller inter-relationship between large firms and small firms has been deficient, despite the growth of small industry. Another aspect of Indian small industry is the high mortality rate, ranging from 30 to 50 per cent. Mazumdar, *et al*, studying the mortality of small-scale industries in South India, observed that financial constraints, raw material scarcities and inadequate demand were major causes.

POLICY DELIBERATIONS

The erstwhile policies of the Government, were directed towards promoting small industry in general, without any special emphasis on developing ancillary industry. Ancillary development was entirely left to the initiative of large industries. The indifferent attitude of large industry [Basu, *et al*, p. 95] and inadequate public policy, apparently retarded the growth of the ancillary industry in India.

Based on such assessment, the Government was contemplating on policy measures to stimulate the growth of the ancillary industry, and raise its output from the 1975 level of about 0.5% of the output of the large houses, to the level of 15%, within 10 years [*The Economic Times*, Bombay, Aug. 29, 1977]. Some of the proposed policy measures were:

1. Limiting the expansion of large industrial firms, to ensure that further growth

takes place in the small industry sector [*The Financial Express*, Bombay, Aug. 14, 1976];

2. Licensing of new projects, subject to the condition that the promoters sponsor ancillary units [*The Economic Times*, Bombay, Sep. 24, 1976];

3. Promoting the long-term contract mode of purchase, to replace the current tender-purchase system followed by the Master Units [*The Economic Times*, Bombay, Oct. 21, 1976];

4. Legislation to ensure payments within 30 days against goods supplied by the ancillary units [*The Times of India*, Ahmedabad, Sep. 29, 1976].

OBJECTIVES OF THE STUDY

The proposed policy of accelerated development of the ancillary industry rests on the belief that ancillary relationship is beneficial for the small firm. Ancillary relationship is conceivably associated with both advantages and disadvantages for the ancillary unit. The advantages are, probably :

1. Ancillary units, due to sales to master units, are less exposed to marketing problems than small scale units;

2. The master units supply some crucial inputs required by the ancillary units to ensure uninterrupted operations;

3. The ancillary unit may also have the benefit of locational proximity to the master unit, which reduces transportation cost and facilitates transfer of technology from the Master Unit.

The disadvantages of the ancillary unit are, perhaps :

1. The larger master unit tends to dictate price and payment terms to the ancillary units;

2. The fluctuations in demand for the products of the master unit affect the demand for intermediate goods supplied by the ancillary unit;

3. The diversification possibility of the ancillary unit are restricted, if special-purpose machinery and equipment have been installed.

The objective of this paper is to examine the following issues: *Have ancillary units fared better than small scale units in India ? In what functional aspects did ancillary units differ from small scale units ?* It is assumed that if ancillary units experience a net advantage from ancillary relationship this would be reflected in their superior performance relative to small scale units.

Framework for Analysis

To carry out this study, the official definitions of ancillary unit and small scale unit were inadequate, because both might produce a mix of intermediate goods and end-products. This study was, therefore, based, on the following sharper definitions :

> *Small Scale Unit :* A small firm with investment in fixed assets less than Rs. 1.5 million that manufactures and markets only end products. (As these firms do not manufacture intermediate goods, they are, by definition, devoid of ancillary relationship).
> *Ancillary Unit :* A small firm with investment in fixed assets less than Rs. 1.5 million that manufactures and supplies only intermediate goods. (By definition, these firms are associated with ancillary relationship).

The economic performance (or overall performance) of a firm was conceptualised as being determined by functional performance. The functions of a small firm include :

* Financial management
* Marketing management
* Production management
* Personnel management

The economic performance of a small firm would depend on how well the entrepreneur managed these functions. If ancillary units

performed better than small scale units, the root of the superior performance would be superior performance in one or more functions.

The enquiry was conducted in two stages. To examine *whether ancillary units performed better than small scale units,* their relative efficiency was assessed. The measure of relative efficiency employed, was ($\mu_1 - \mu_2$) where μ_1, μ_2 were the mean economic performance of the populations of ancillary units and small scale units respectively. The following is a statement of the single-tailed test of hypotheses about the population means, μ_1, μ_2 :

$H_0 : \mu_1 = \mu_2$ (null hypothesis)
$H_1 : \mu_1 > \mu_2$ (alternate hypothesis).

These hypotheses were alternately tested by the parametric t—test [Walker, 1965] and the non-parametric Mann-Whitney "U" test [Siegel, 1956]. The alternate measures of economic performance employed included,

1. gross profits/total assets,
2. gross profits/total fixed assets, and
3. gross profits/sales. As these are all ratios, the effect of size of the small firm on profits would be neutralised.

To examine *the functional differences between ancillary units and small scale units,* two applications of multiple discriminant analysis were employed [Kerlinger, 1973] :

1. Finding a representative *linear* combination of the predictor variables that maximised among-group relative to within-group separation and analysing which variable accounted most for inter-group differences. (The assumption was that within-group covariance and dispersion were equal across groups. No assumptions regarding the probability distributions of the groups need be made).
2. Testing whether significant differences existed among the mean values (taking all predictor variables simultaneously) of the groups, (The assumptions were that within-group covariance and dispersion were equal across groups and that the groups were distributed as multivariate normal).

The predictor variables chosen to represent the performance of the various functions were as follows :

1. Total Fixed Assets to Total Assets ratio (TFA/TA): This represents the composition of fixed and working assets, and a high value of this ratio indicate reduced liquidity.
2. Sales as a ratio of Total Current Assets (S/TCA): This represents working capital turnover.
3. Accounts Receivable to Sales ratio (AR/S): A measure of cash collection effort.
4. Delay in Payment (DP) : The average time in days for an invoice raised by the small firm to be paid, as a ratio of 90 days.
5. Marketing Effort (MC/TC) : The ratio of expenditure on advertising and sales promotion to total cost was treated as a surrogate measure of marketing effort.
6. Sales as a ratio of Total Fixed Assets (S/TFA): This represents marketing management.
7. Capacity utilisation (CUS): Measured as a ratio of the output of the firm to the entrepreneur's estimate of the firm's capacity. This represented capacity management.
8. Percentage Defects (PD): The ratio-variable sales returns to sales-net-of-returns was used as a proxy for percentage defects. This represents quality management.
9. Labour Turnover (LT): This variable was measured as the ratio of the sum total of exiting and entering personnel to the total personnel in employment at the beginning of the year. It represented personnel management.

Variables 1 to 4 represented the performance of the finance function, 5 and 6 marketing, 7 and 8 production, and the last variable, the performance of the personnel function. To select the representative function, the criterion of lowest probability of misclassification was employed. Once the representative function was identified, the following measure was computed :

$$\frac{/ l_i d_i /}{\Sigma / l_i d_i /}$$

where l_i = discriminent coefficient

$d_i = Xi_1 - X_{ij}$

X_{ij} = i^{th} predictor variable

j = 1, 2 the two groups, namely, Ancillary Units and Small Scale Units.

This measure indicated the contribution of the predictor variables (X_i) to the discrimination between the two groups. The F — test was employed to examine whether ancillary units and small scale units were statistically different from each other on the basis of the performance of the various management functions considered simultaneously. The F – test is simply a multi-dimensional analogue of the t—test described earlier.

SAMPLING AND DATA COLLECTION

There is a dearth of published accounting data on small firms in India. This necessitated the collection of primary data for this study. The questionnaire-cum-interview method was adopted.

Due to lack of information of adequate numbers of firms conforming to the researcher's definitions of small scale unit and ancillary unit, statistically representative sampling was precluded. A sample of 35 small scale units manufacturing *industrial machinery* whose accounts were maintained by one commercial bank was selected. Of these, 10 agreed to cooperate in this study. A sample of 51 ancillary units manufacturing *components for industrial machinery*, and located in one industrial estate sponsored by a Master Unit was drawn. Only 7 firms extended cooperation. Qualitative and quantitative data pertaining to 1975 were collected from both samples.

It is pertinent to note, that business fluctuations would equally affect the demand for *industrial machinery*, and *components for industrial machinery*. This is because the demand for components is derived from the demand for machinery. Firms making machinery and those manufacturing components were, therefore, considered as falling in the same broadly-defined industry. Thus, the statistical tests would not be vitiated by industry influence on performance.

FINDINGS

A profile of characteristics of the sample firms was constructed (Table 2) to serve as an

Table 2

*Profile of Characteristics of the Sample Firms**

Characteristics	Small Scale Units	Ancillary Units
1. Sample Size	10	7
2. Location	City A	City B
3. Mean age (years)	15	11
4. Mean fixed assets (Book value Rs. million)	0·735	0.22
5. Mean sales (Rs. million)	2.782	1.08
6. Mean no. of personnel	96	32
7. Percentage of firms employing high technology**	36	80
8. Percentage of firms which receive payments within 3 months	90	40
9. Principal problem area	Finance	Finance
10. Sales contract with master unit	No	Yes
11. Mean no. of master units	Nil	4

Symbols : * Based on firm-level primary data for 1975 ** These were the perceptions of the entrepreneurs.

aid in interpreting the results of the statistical tests. The sample small scale units were slightly older but definitely larger in size (on the basis of mean fixed assets, mean sales and mean number of personnel) than the sample ancillary units. The difference in size is partly because manufacture of end-products requires more resources than the manufacture of components. The small scale units employed high technology less often than the ancillary units which had access to transfer of modern technology from the Master Units. All the ancillary units relied on a few (average 4) master units for sales and this was attributed as a cause for delays in payment (only 40% of the firms received payments within 3 months of delivery of goods). Finance was the principal problem area in both cases.

The results of the t—tests and the Mann-Whitney "U" test of the hypotheses regarding the equality of the two populations' mean economic performances are presented in Table 3. The mean performance of ancillary units was not significantly different from that of the small scale units by the t—test (computed t less than critical value) and the Mann-Whitney "U" Test (Computed "U" higher than critical value) on the three performance measures. *The conclusion was that ancillary relationship as prevalent in India conferred no net advantage on the small firm.*

The results of the multiple discriminant analysis are contained in Table 4. Only a selected few of the computed multiple discriminant functions are presented in this table. The representative function (selected by the procedure described earlier) has been marked with a triple asterisk against the serial number. Ancillary units were significantly different from small scale units on the basis of a linear combination of the following predictor variables (functional performance characteristics):

Accounts Receivable/Sales (AR/S) = 37.7%

Sales/Total Fixed Assets (S/TFA) = 5.9%

Percentage of Defects (PD) = 52.1%

Labour Turnover (LT) = 4.3%

The extent to which each variable accounted for the inter group differences is indicated above. Accounts Receivable/Sales, and Percentage of Defects together accounted for 90% of the differences. *The conclusion was that management of accounts receivable and output quality constituted the crucial functional differences between ancillary units and small scale units.* The interpretation is that the entrepreneur of the ancillary

Table 3

*Test for Equality of Mean Economic Performance of Ancillary Units (n_1=7) and Small Scale Units (n_2=10)**

Type of Test		Performance Measure		
		Gross Profit / Total Assets	Gross Profits / Total Fixed Assets	Gross Profits / Sales
Parametric t-test	t (Computed)	0.704	.645	1.131
(assuming normal distributions and unequal variances)	degrees of freedom	10	9	11
	t (critical)	1.81	1.83	1.8
Non-parametric Mann-Whitney "U" Test	U (Computed)	27	30	24
	U (Critical)	17	17	17

Symbols . *Based on primary data for 1975.

Note : The computed t, U values are not significant at 95% level of confidence.

Table 4

Multiple Discriminant Functions of Ancillary Units (n_1=7) and Small Scale Units (n_2=10)

No.		AR S	DP	MC TC	S TFA	CUS	PD	LT	F (df)	Pr
1		−11.58				−6.02	−34.5		7.2* (3,13)	1.23
2			−9.25			−2.49	−26.8		7.6* (3.13)	1.27
3		−10.9			−.29		−32.1		7.1* (3,13)	1.22
4			−8.86		−.037		−26.9		7.4* (3,13)	1.25
5			−9.25		−.016	−2.443	−26.57		5.3* (4,12)	1.27
6				86.4	−.425		−42.4	−21.2	6.2* (4,12)	1.37
7	***	−13.6 (37.7)			−.349 (5.9)		−51..2 (52.1)	−15.6 (4.3)	7.2* (4,12)	1.48
8			−8.13		−.037		−31.2	−3.89	5.3** (4,12)	1.27

Symbols : For symbols $\frac{AR}{S}$ ..... LT, refer the text.

F (df) = Computed F statistic (with degrees of freedom)

Pr = The probability of misclassification is twice the probability that a standard normal variate takes a value greater than Pr. The higher the Pr value, the lower the probability.

* Indicates significant at 99% level of confidence

** Indicates significant at 95% level of confidence

*** Indicates the representative discriminant function, with figures in parentheses indicating the percentage contribution by the variables towards discrimination between the two groups.

unit has to pay greater attention to managing problems of product quality and accounts receivables.

CONCLUSION

The finding that the mean economic performance of ancillary units was no different from that of small scale units indicates that there was no net advantage for ancillary units, from ancillary relationship as prevailing in India. There are two interpretations for the equal mean economic performance. The first question that could be raised, is whether small scale units that bear the *additional risk of marketing* should be earning the same average returns as ancillary units. The second viewpoint could be, that ancillary units are an *efficient form of small enterprise*, considering the fact that they have mastered modern technology to produce sophisticated quality components at *prices administered* by the Master Units, and yet their performance was not inferior to small scale units. The moot question is whether reward for small industry should be in compensation for *market risk bearing* or *efficiency*.

Multiple Discriminant Analysis confirmed that there were functional differences between ancillary units and small scale units, management of product quality and accounts receivable being important. While quality management is an exclusive measure of the entrepreneur's capability, receivables management is dependent on the entrepreneur's efforts and the payment policy of the Master Unit. Only 40% of the sample ancillary units received payments within 3 months, against 90% of the sample small scale units. The sample small scale units often received payments as they manufactured machinery to order. If payments had been made on time, perhaps the mean economic performance of ancillary units would have been higher than that of small scale units.

Under the prevailing conditions, entrepreneurs would be indifferent between establishing ancillary units and small scale units, provided they are aware of the situation. The Government's proposals for accelerated development of the ancillary industry would prove futile, If ancillary development is preferred, a reorientation

is necessary with legislation to protect ancillary units and incentives to Master Units to encourage purchases from ancillary units.

Excise duty relief may be one such incentive. □

REFERENCES

Publications

1 Bass, L. W., Technical and Managerial Help for Small Enterprises. *World Development*, Vol. 4, No. 4, 1976.

2 Basu, S.K., Ghosh, A., and Ray, S., *Problems and Possibilities of Ancillary Industries in a Developing Economy*, Calcutta; The World Press Ltd., 1965.

3 Bhandari, P.M., *A Handbook of Small Scale Industries*, Calcutta : The Peerless Publishers, 1975.

4 Department of Industrial Development, Ministry of Industry and Civil Supplies, Government of India, *Guidelines for Industries 1975-76*, Delhi : Indian Investment Centre, 1975.

5 Development Commissioner, Small Scale Industries, Ministry of Industry and Civil Supplies, *All-India Report on the Census of Small-Scale Industries Vol. I.* New Delhi : Government of India Press, 1976.

6 Kerlinger, F.N., and Pedhazur, E.J., *Multiple Regression in Behavioural Research*, New York ; Holt, Rinehart and Winston Inc., 1973.

7 Lekdawala, D.T. (ed.), *A Survey of Research in Economics. Vol. V-Industry* Bombay; Allied Publishers, 1975.

8 Lakshman, T.K., *Problems and Prospects of Ancillary Industries in a growing Economy* Bangalore : Rekha Publications, 1970.

9 Mazumdar, H.K. and Naj, A., *Survey of Mortality of Small Scale Industries in South India-Summary of Report*, Hyderabad : The Indian Institute of Economics, 1977.

10 Shalig Ram, K.R., "Focus on Small Industry", *Indian International Centre Quarterly*, Vol. 5, No. 2, 1978.

11 Shalig Ram, K. R., "Relative Efficiency of Ancillary Units and Small Scale Units", *Vikalpa*, III, 4, Oct. 1978, pp. 279-84

12 Shalig Ram, K. R., *Economic Performance of the Ancillary Industry in India : Managerial and Policy Implications* Doctoral Dissertation Series, Publication No. 7918429, Ann Arbor, Michigan, University Microfilms International 1979, 160 p.

13 Siegel S., *Nonparametric Statistics for the Behavioural Sciences*, International Student Edn. Tokyo : Mc. Graw Hill Kogakusha, 1956, 312p.

14 Vakil, C.N. and Mohan Rao, U.S., (eds.) *Industrial Development of India* : Policy and Problems, New Delhi : Orient Longman Ltd., 1973, 504 p.

15 Vepa, R.K., *Small Industry in the Seventies*. Delhi : Vikas Publications, 1971, 307 p.

16 Walker, H.M. and Lev, J., *Statistical Inference*, Calcutta Oxford and IBH Publishing Co., 1965, 510 p.

News items

1 "Ancillaries Growth : Excessive Investments in Mother Plants will go", *The Financial Express*, Aug. 14, 1976

2 "Big Units May Share Output with Small", *The Economic Times*, Bombay Sep. 24, 1976

3 "Law to Protect Small Units on Anvil", *The Times of India*, Ahmedabad, Sep. 29, 1976.

4 "Developing Ancillary Units: 7-Point Plan for Public Sector", *The Economic Times*, Bombay, Oct, 19, 1976.

5 "Developing Ancillary Around Government Units : Long Term Contract System Favoured", *The Economic Times*, Bombay, Oct. 21, 1976

6 "Ancillaries : New Strategy for Growth", *The Economic Times*, Bombay, Aug. 29, 1977

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Performance of Contract System of Execution of Construction Projects

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Most of the organisations because of their Inability to execute the construction projects themselves departmentally and due the multifarious problems faced in the same, resort to contract system. The basic parameters reflecting the performance execution through contract systems are Time over run and Cost over run. To improve the performance. these two parameters should be reduced to minimum. This paper deals with the causes of Time over run and Cost over run and suggests methods to reduce the same.

Introduction

In any project, the construction activities are inevitable. In the wake of unprecedented development, large scale construction activities have come up, which are being executed through contract system. Such construction activities involve both Government departments and Public and Private sector undertakings. Due to their inability to execute the works departmentally, or due to the multifarious problem faced in the same, these organisations resort to contract system. Even some construction undertakings such as National Building Construction Corporation, Bridge Construction Corporation etc., who act as contractors for other organisations, execute the works through other contractors establishing thereby that the contract system is inevitable.

Whether the contract system is all too efficient is a debatable point, more so the way in which it is practised. A study by the Central Building Research Institute, Roorkee, has established that none of the various contract systems is very satisfactory, although performance of the Lumpsum Contract system is comparatively better.

The basic parameters reflecting performance of contract systems are *Time over-run* and *Cost over-run*. A single performance Index can reflect the combined effect of both these

parameters and can be defined as follows.

$$\text{Performance Index} = \frac{\text{Estimated cost of the project}}{\text{Actual cost of the project}} \times 100$$

$$= \frac{\text{Estimated cost}}{\text{Estimated cost} + \text{cost over run} + \text{opportunity loss due to time over-run}} \times 100$$

Thus the performance can be improved by reducing the cost over-run and time over-run.

Causes of Time Over Run and Cost Over Run

1) Causes related to the management

   a) Delay due to lack of clarity and incomplete specifications and drawings.
   b) Delay in handling over of site
   c) Delay due to a lot of formalities
   d) Delay due to non-availability of fund on time.
   e) Delay due to non-availability/non-issue of materials on time.
   f) Delay due to lack of coordination among concerned departments.
   g) Cost over run due to items added during execution.
   h) Cost over run due to increase in prices of inputs during execution.

2) Causes related to the contractors

   a) Bad Planning
   b) Professional incapability
   c) Lack of finance
   d) Lack of motivation.

Methods to Improve Performance

On the examination of above causes of Cost over-run and Time over-run the following conclusions are drawn.

a) Time over-run results in opportunity loss and some times increase in cost of materials because of market fluctuations.
b) Increase in additional work during execution due to vague specifications, frequent changes in design, drawing and planning results in cost over run. Some times increase in prices of items during the course of execution also results in cost over-run.

Thus for improving the performance the following guide-lines are suggested.

1) Establish the work logic and activity relationship through a network diagram for the project and plan the execution work accordingly. Net work analysis should be adopted as far as possible in all major projects and the completion time should be arrived at based on critical path analysis. The standard deviation for the various activities and the critical path should be arrived at. The scheduled time given for the completion of the project should normally be the time taken for the critical path + three times the standard deviation of the total critical path, so that the probability of completion of project is practically 100%.

2) Spell out the specifications, drawings and work content in clear terms.

3) Simplify and stream line decision making procedures.

4) Select proper contractors. The method of selecting the contractors, for different works, taking into account their past experience, financial soundness and capacity to undertake the desired magnitude of works, will help in many a way. It will help in weeding out incompetent parties quoting for high value of work. It will also help in quickening the process of entering into agreement.

5) Fix obligations and accountability of contracting parties in the event of delay on either side.

6) Motivate contractors to complete work in estimated time.

The first four come under the direct perview of the management. The last can be achieved by

introducing a rational compensation for delay clause in the contract which should be fair to both contracting parties. A rational compensation for delay clause suggested by the author is given below :

Project Delay and the Cost of Capital

The delay caused in a project may be either due to the contractor or due to the employer. The delay caused by the employer can be classified into two types, one the direct delay like delay in the issue of materials, issue of drawings, delay in handing over the site etc; and the other, the indirect delay caused by the non-payment of bills in time, non-releasing of security in time etc. Non-payment of bills in time by the employer amounts to the blocking of funds of the contractor which forces the contractor to arrange for more funds at a particular period of time, than the normal requirement, thus increasing the cost of capital. If the contractor could not arrange for more funds the project is delayed. This indirect delay can be compensated by paying the contractor the increase in the cost of capital. The direct delay caused by the employer which can be quantified is deducted in the total recorded completion time.

After accounting for all the above, the balance period of delay, which is mainly due to the contractor, should be compensated by the contractor by way of penalty. Here the important point is, that as the increase in cost of capital is being paid to the contractor, the contractor will have no reason to delay in arranging for more funds whenever it is required, and so the indirect delay will be fully eliminated.

So, the net penalty for delay will be the gross penalty calculated minus the increase in the cost of capital.

Formula for Calculation of Compensation for Delay

The net penalty to be levied on the contractor should be a function of the probability completion of the project (Pc), the percentage of delay of the project (D), the cost of capital (C), a constant substituted to control the total percentage of delay within which the full penalty is to be recorded (K_3) and the total percentage of the value of the work (K). That is, the net panalty $= f(PC, D\ CK_3, K)$, considering the inter-relationships between the various factors, the formula for net penalty can be formulated as

$$\text{Net penalty} = (K_1 + tK_2)\ P_C\ K_3\ D\text{-}C \qquad (1)$$

In this formula to suit the departmental procedures the total percentage of the value of work K, has been split up into (K_1+tK_2) which is equal to the total security deposit.

As per the departmental procedure, the EMD is received during the tendering of the work and it is converted into security deposit. The balance security deposit is recovered in 4 equal instalments in the running bills. So, in the formulas,

K_1 = Earnest money deposit

K_2 = Equal instalment amount of balance security deposit deducted from the running on Account bills.

t = 1, 2, 3, 4, which represents the number of bills paid at the time of consideration.

P_C = Probability of completion of the project in the scheduled time calculated from Network.

D = Percentage of delay.

C = The increase in the cost of capital.

K_3 = A constant which can be assigned any value depending upon the total percentage of delay within which the full penalty is to be recovered, $K_3=1$, indicates that at 100% of delay of the project the penalty will be recovered in full and for the percentage of delay less than 100%, the penalty will be proportionate. $K_3=2$ indicates that at 50% of delay of the project the penalty will be recovered in full and for the percentage of delay less than 50% the penalty will be proportionate. That is for 30% of delay the penalty will be 60% of the total penalty. $K_3=3$ indicates that at 33 1/3% of delay of the project

the penalty will be recovered in full and so on.

As per the prevalent practice and as recommended by Bureau of Public Enterprises, the total security deposit will be 10% of the first one lakh of the contract value plus $7\frac{1}{2}$% of the next one lakh of the contract value plus 5% of the balance contract value and the total amount thus calculated will be limited to one lakh.

As per normal practice the total percentage of the value of work used for calculation of the penalty should be less than 50% in which the maximum penalty will become less than 5% of the contract value. Considering this, the formula (1) will not hold good for contract values beyond 20 lakhs, as ($K_1 + t\ K_2$) is limited to 1 lakh which is less than 5% of the contract value.

For contract value of beyond 20 lakhs, the formula can be slightly modified so that the maximum penalty is not less than 5% of the contract value. The modified formula for penalty for delay for contract value beyond 20 lakhs will be

(2) $[K_1 + t\ K_2 + O\ .05\ (A - 20,00,000)]\ P_C\ D\ K_3 - C$

Where A = Total contract value, if the contract value is less than 20 lakhs. The term in the above equation will be zero for all values less than Rs. 20 lakhs.

In the formulas suggested, if the contractor fails to take up one work, penalty will be equal to EMD. That is the EMD will be forfeited. After doing some work, if the contractor abandons the work, the penalty will be the EMD plus the instalments of the security deposit so far deducted from the running bills. That is the security deposit on hand will be forfeited. In such cases the probability of completion of the project does not come into picture as the project has not been either taken up or completed. The percentage of delay will also be taken as full delay as it is uncertain to say when the project will be taken up further, after fixing up another agency.

The sixth can be achieved by introducing an incentive scheme for the contractors which will motivate them to complete the work early if not at least in estimated time. A model incentive scheme suggested by the author is given below.

Incentive

The author in his earlier work has advocated that the standard time for any project can be calculated from the PERT Network of the project as critical path time (TE) plus three times standard deviation of the critical path (σ). The total time saved due to early completion of the project is equal to (Standard time-Actual time) and if the average cost incurred per day by the management in terms of supervision and opportunity cost over the total span of project execution then the total saving by early completion of the project can be calculated as follows.

Total saving = (Standard time—Actual time) x (Average cost per day).

If the incentive to be paid is 50% of the total saving then Incentive to be paid will be = $\frac{1}{2}$ (Standard time—Actual time) x (Average cost per day).

Productivity
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Comparative Cost Analysis Of Some Rice Polishers

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Unit cost of operation for four different polishers were studied. The results indicated that the cost of operation of parboiled paddy is consistently higher than that of raw paddy. Further, the unit cost of polishing is lowest with a vertical cone type polisher and highest for a horizontal disc type polisher.

Rice polishing is an important and a critical operation in the rice milling process. It is also the most energy consuming operation and is responsible for the final quality and quantity of the rice obtained from a mill. A faulty design or adjustment of a rice polisher may completely disfigure the economy of a rice mill. A good polisher may produce rice with *broken* (pieces smaller than half a rice) as little as 5 per cent whereas a faulty polisher may result in brokens as high as 50 per cent. Moreover, energy consumption of the polishers have been found to vary considerably. Therefore, proper selection of a polisher for a rice mill is a factor of great importance.

At present, polishing machines of different type and make are available in the country with variation in design and construction materials. However, there is no independent or impartially obtained data on comparative performance of various machines. Such an information is necessary for guiding a purchaser to choose a particular machine for meeting his operational requirements. The result of such tests can be useful to the manufacturers also, in bringing about improvements in their existing machines. With these ends in view, a comparative study of some polishers has been made.

Methods and Materials

Four different polishers, each representing a class of polishers, were selected to study their cost in relation to output. These were:

1. Vertical Abrasive Cone polisher (Dandekar polisher).
2. Horizontal Abrasive Disc polisher (Kisan polisher).
3. Horizontal Abrasive and Friction polisher (Satake polisher).
4. Huller polisher (Barthakur polisher)

Before the actual trials were conducted, the polishers were adjusted for their best possible operation. It was done by carrying out pilot trials and plotting calibration curves for the standard 4-5 per cent polish of Jaya variety. The curves were later used to adjust the machines. All the machines were, thus, adjusted to get a polish range of 4 to 5 per cent. After the proper adjustments were made, well graded brown head rice sample of 5 kg was polished by each machine. Trials were conducted both for raw and parboiled paddy (Jaya variety). Polish percentage, capacity, broken percentage and energy consumption for whitening the rice in machine were measured. The unit cost of operation of each machine was then calculated. The cost of operation included the fixed costs such as depreciation, interest on investment and other charges, and variable costs such as repair and maintenance, energy costs, labour charges, etc. For comparing capital cost, the prices of the machines were ascertained. The operational costs were estimated for each type of machine, based upon assumed annual use, current rate of interest, labour charges and machine capacity. The unit costs were expressed in terms of rupees/tonne of brown rice to the standard polish of 4 to 5 per cent.

RESULTS

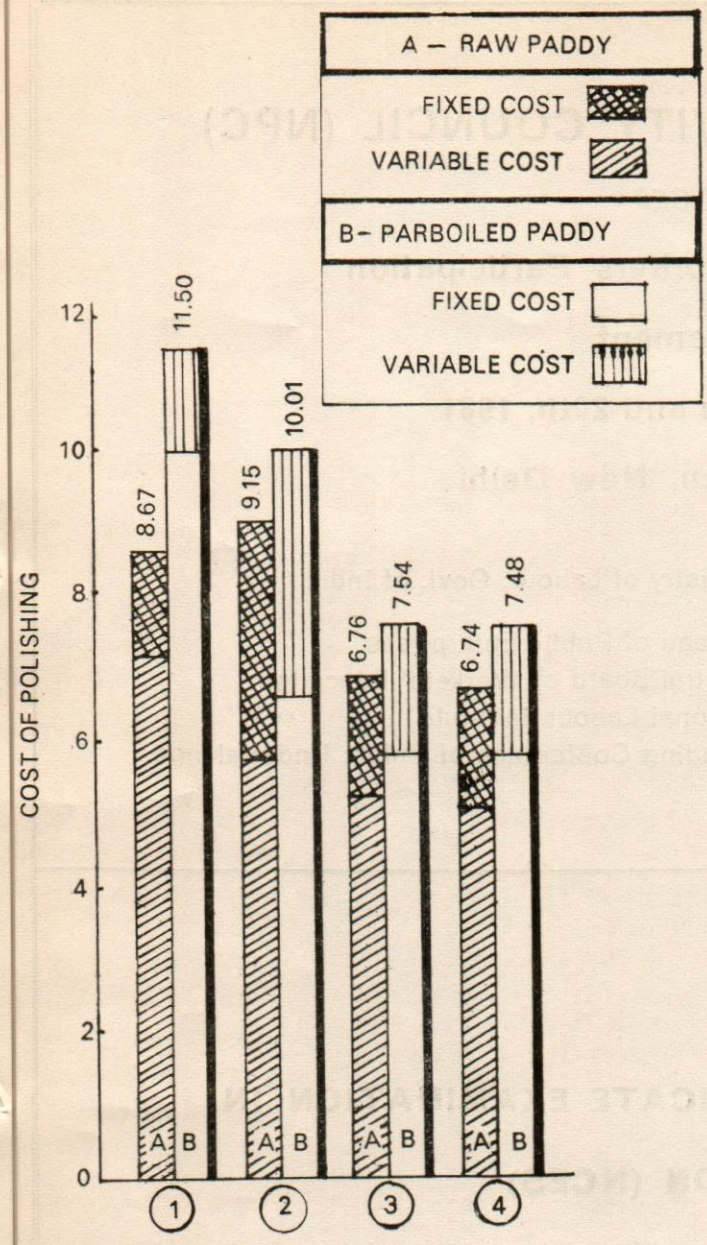
A summary of the costs data of the four rice polishers, under test is given in Table 1. The final results are shown in the form of a histogram (Fig. 1). These results indicate that unit cost of operation of parboiled paddy is consistently higher than that of raw paddy. This is because energy requirements for polishing parboiled rice are higher than those for raw rice. The increased energy costs of parboiled rice are contributed to the hardening of the grain during parboiling process.

The results also show that unit cost of polishing both raw and parboiled rice is the lowest with the vertical cone type polisher whereas it is highest for a horizontal disc type polisher. The unit costs for a huller type polisher compares well with a vertical cone type polisher. The higher costs in case of disc type polisher is indicated due to the higher repair and maintenance cost of the machine. The high unit cost of polishing for satake polisher is mainly due to higher initial investment; the variable costs compare well with any other type of polisher. The low unit costs for vertical cone polisher and

Table : 1

Cost of data of rice polishers

Polishers	Fixed costs (Rs. per tonne)						Variable costs (Rs. per tonne)						Total cost (Rs. per tonne)	
	Raw			Parboiled			Raw			Parboiled			Raw	Parboiled
	Dep.	Int	Oper.	Dep.	Int.	Oper.	Repair & Main	Energy costs	Labour	Repair & Main	Energy costs	Labour		
Verticle Abrasive Cone	0.79	0.40	0.45	0.79	0.40	0.45	2.60	1.60	0.90	2.60	2.34	0.90	6.74	7.48
Horizontal Abrasive Disc.	0.53	0.26	0.70	0.53	0.26	0.70	1.55	2.31	1.41	1.55	3.09	1.41	6.76	7.54
Horizontal Abrasive & Friction	0.41	0.20	0.85	0.41	0.20	0.83	5.55	0.02	1.66	5.55	2.85	1.66	8.67	11.50
Huller	1.90	0.95	0.51	1.90	0.95	0.51	2,90	1.87	1.02	2.90	2.73	1.02	9.15	10.01



1 HORIZONTAL ABRASIVE DISC POLISHER

2 HORIZONTAL ABRASIVE AND FRICTION POLISHER

3 TRADITIONAL HULLER POLISHER

4 VERTICAL ABRASIVE CONE POLISHER

Fig. 1 Comparative Cost of Polishing in rupees, per tonne of Brown Rice.

huller type of polisher are attributed to the low repair and maintenance costs, energy costs and labour charges per tonne of material handled.

CONCLUSION

From the results, it can be concluded that both the fixed costs and variable costs are the controlling factors for unit operational cost of a machine. A higher investment on the machine may increase the fixed cost whereas higher repair costs, energy costs and labour costs will increase the variable cost of machines operation. The conclusion that can be derived from the study is that a cone type polisher is more favourable than any other type of polisher. Although the costs of a huller type polisher compare well with the cone type polisher, yet, its performance index being very low, it does not stand in comparison with the cone type of polisher. □

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Productivity
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Productivity Trends In A Cement Plant

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Sectoral economic performance depends upon the efficiency with which resources are employed to achieve the given targets. Thus, productivity of the factors of production determines the growth path of an industrial enterprise. In the unit under study, although, the number of workers has increased, labour requirement per tonne has decreased, as a result of increased production and capital intensity.

Developmental strategy of a country is a function of relative economic performance of all sectors. And, the sectoral performance depends upon the efficiency with which the resources are employed to achieve the given targets. Thus, productivity of the factors of production determines the growth path of an industrial enterprise. An attempt has been made in this paper to analyse and explain trends in productivity in a cement plant from 1955 to 1975. (The name of the plant has been kept as secret).

Sources of Data

The data for purposes of analysis have been obtained from the Annual Reports of the company for various years. Data relating to physical production, installed capacity etc., have been acquired from the publications *Cement Production and Despatches* and *Cement* published by the Office of the Cement Controller, Delhi, and Cement Manufacturers Association Bombay, respectively. Supplementary details have been obtained from the *Weekly Replacement Service*, Stock Exchange, Bombay.

Variables Used :

The main analytical variables used are

V = Net Value Added

L = No. of Workers

K = Net adjusted Capital for Capacity Utilisation

W = Wage Rate per Worker (in rupees)

r = Rate of Return per unit of Adjusted Capital

I_t = Kendrick's Index of Total Productivity which measures productivity if the factors are rewarded at base year prices.

Data Processing and Price Deflation

Net value added has been obtained as the difference between total output and inputs in value terms at current prices. The figures so obtained have been deflated by the index of average ex-works prices fixed by the Government from time to time at the recommendations of the Tariff Commission, appointed for this purpose, for this company. Similarly, total net capital has been obtained from various reports after making adjustments for additions and deductions. The figures have been deflated by the combined average index constructed from the indices of logs and timber, construction, metal products, machinery and transport equipments and cost of living indices. The deflated figure so obtained has been multiplied by the capacity utilisation factor obtained by dividing the total physical production (tonnes) by the total installed capacity during different years. The adjusted capital has been divided by the total number of workers including skilled, semi-skilled, un-skilled, clerical and supervisory persons during respective years to obtain net adjusted capital per worker.

Wages and Salaries have been obtained from profit and loss accounts for the relevant years and deflated by the cost of living indices on the all-India basis. As at regional level, separate indices are not available, hence, it is assumed that increase in money wage rate takes place in response to rise in prices. The total wages and salaries so deflated have been divided by total workers to get wage rate per worker. Similarly, out of the total value added, the total real wages have been subtracted to arrive at share attributable to capital. The share so obtained has been divided by the net adjusted capital to arrive at rate of return (r) per unit of adjusted capital. The total wage payment per worker (W) has been divided by r to get wage-renal ratio. All variables have been deflated at 1951-52 prices.

Productivity : Some Measurement Problems

The accurate measurement of productivity is very difficult. Since it is a by product of the joint efforts of all factors of production combined in a certain proportion, it is difficult to isolate the contribution of each of them. The factors themselves are heterogeneous. The technological changes are so fast embodied in capital goods, that it is difficult to get an accurate value of capital employed. Moreover, method of production or quality of inputs also change. All these affect quantity of each. Therefore, the contribution of each factor to Productivity is a difficult task.

The concepts here used are labour, capital and total productivity

Labour Productivity:

It is the net value added or output per worker.

Capital Productivity:

It is the net value added per rupee of net capital adjusted for capacity utilisation.

In this context rate of return ' r ' has also been calculated as a measure of Capital Productivity. Rate of return has been calculated as under :

$$\frac{\text{Net Value Added-Total Wages and Salaries}}{\text{Total Net Adjusted Capital}}$$

Total Factor Productivity:

It is the output per unit of input. Moreover, we have calculated Kendrick's Index (I_t) of Total Factor Productivity when the factors (labour and capital) are rewarded at base year prices.

Interpretation of Results

Productivity Ratios and Indices at constant prices (1951-52) are presented in Table 1. It can be seen that Labour Productivity $\left(\frac{V}{L}\right)$ has shown an abrupt increase in 1957. Except for 1958, it has almost doubled in 1959. It has

Table : 1

Productivity Ratios and Indices (at 1951-52 Prices)

Period	Labour Productivity	Indices of Labour Productivity	Capital Productivity	Indices of capital Productivity	Rate of Return of per unit of Adjusted Capital
	$\frac{V}{L}$	V/L	$\frac{V}{K}$	V/K	r
1955	596.56	100.00	0.3998	100.00	0.2671
1956	537.20	90.03	0,0389	9.72	-0.0392
1957	4344.36	728.11	0.2285	57.15	0.1517
1958	2722.01	456.20	0.3503	87.66	0.2252
1959	7018.94	1176.37	0.2998	74.98	0.2015
1960	7618.10	1276.79	0.2411	60.30	0.1492
1961	7121.97	1193.64	0.2648	66.23	0.1735
1962	4470.58	749.26	0.2312	57.82	0.1200
1963	7943.47	1331.32	0.3575	89.44	0.2585
1994	6453.41	1081.59	0.4103	102.62	0.2793
1965	7008.24	1174.58	0.4002	100.10	0.2821
1966	7160.53	1200.10	0.4675	116.93	0.3342
1967	7356.37	1232.92	0.4581	114.58	0.3237
1968	7412.57	1242.34	0.4387	109.72	0.3013
1-4-69 to 31-3 70	10955.41	1836.21	0.6398	160.02	0.4396
31-3-71	11361.02	1904.10	0.3132	78.83	0.2106
1972	8056.49	1350.26	0.3737	93.47	0.1848
1973	7199.16	1206.58	0.2633	65.85	0.0720
1974	7724.24	1294.58	1.2585	314.78	0.6019
1975	13840.46	2319.65	1.2785	569.90	1.5388

maintained a fluctuating trend throughout the decade 1958-68 with a sudden rise in 1970. Except for a decline during 1972-1974, it has reached the highest figure in 1975. Thus, on the whole, it has shown an increasing trend.

With regard to Capital Productivity $\left(\frac{V}{K}\right)$, though the trend is increasing but there are minor fluctuations. But it has shown abrupt increases in 1974 and 1975.

Another measure of capital productivity, i.e., rate of return (r) per rupee of adjusted capital has been abnormally low (negative) during 1956 and 1973. This is because of low level of net value added. The rate of return was the highest in 1975. When it was 1.5388.

Real Wages per Worker:

Real wages per worker (W) was very low in 1955, (Rs. 198.04 at 1951-52 prices) but it has increased in subsequent years and has shown rising trend throughout the period so much so, it reached Rs. 5228.57 in 1973 and then decreased abruptly to Rs. 449.85 in 1975 (Table 2), possible reason could be the rise in the cost of living indices.

Table 2

Productivity Ratios (at 1951-52 prices)

Period	Annual Real wage payment per worker W	Wage Rental Ratio $\frac{W}{r}$	$\frac{\text{Total workers}}{\text{Total Tonnes produce}}$	Fixed Capital per worker $\frac{K}{L}$
	Rs.		Rs.	Rs.
1955	198.04	741.46	0.0605	1491.95
1956	1078.55	-27514.03	0.0066	13801.21
1957	1459.88	9623.51	0.0047	19009.63
1958	973.10	4321.08	0.0085	7764.52
1959	2301 45	11421.63	0.0032	23411.49
1960	2903.44	19460.07	0.0023	31587.99
1961	2455.23	14151.22	0.0026	26890.96
1962	2150.07	17917.27	0.0034	19329.93
1963	2199.66	8506.03	0.0029	22298.86
1964	2060.32	7376.75	0.0040	15724.83
1965	2066.83	7326.59	0.0035	17510.90
1966	2042.38	6111.26	0.0038	15314.40
1967	2158.50	6668.23	0.0034	16055.45
1968	2320.87	7702.86	0.0034	16895.12
1-4-69 to 31-3-70	3427.45	7796.76	0.0028	17123.11
1971	3771.12	17906.56	0.0023	36034.68
1972	4071.84	22033.78	0.0023	21557.51
1973	5228.57	72619.08	0.0016	27336.31
1974	4029.93	6695.34	0.0022	6137.26
1975	449.85	2919.06	0.0018	6072.75

Wage Rental Ratio $\left(\frac{W}{r}\right)$

Generally wages are not equal to the value of the marginal product of worker. It is possible only in case of perfect competition. Similarly, rate of return is the reward of capital that should also be equal to the marginal product of capital. Thus, the wage rental ratio indicates the ratio of marginal product per worker to marginal product per rupee of adjusted capital. If wage rate is equal to marginal product, then the ratio indicates the amount of capital required to be invested in order to get the product produced by one worker associated with capital provided capital and labour can be perfectly substituted for each other. From Table 2, it can be seen that the ratio $\left(\frac{W}{r}\right)$ is negative in 1956 (-27514.03) because of

negative value of rate of return. It has also shown rising trend but is subjected to many fluctuations. Because of rising real wage rates, the ratio indicates that relatively greater capital is required for purposes of investment, in order to get marginal product equal to that produced by one worker.

Labour Requirements per Tonne:

If we visualise whether labour efficiency has increased or otherwise or whether labour requirements per tonne has increased we should calculate the ratio $\frac{\text{Total workers}}{\text{Total Tonnes produced}}$

The ratio indicates that there are many fluctuations but the trend is declining. The declining ratio shows that labour required per tonne has decreased over the period. This might have happened to change in capital-labour ratio. Increased capital per worker may be due to technological changes in the industry.

Capital Intensity:

The above reduced labour requirements per tonne can be reconciled by the fact that capital-labour ratio $\left(\frac{K'}{L}\right)$ has increased over the period, though it has shown fluctuations throughout the period (Table 2, col. 5). The ratio has declined during 1974 (6137.26) and 1975. (6072.75) but that might have been affected by some changes in employment policy and replacement of assets.

Indicators of total Productivity

$\frac{Output}{Input}$:

The $\frac{\text{Output}}{\text{input}}$ ratio (Table 3), shows fluctuating trends over the entire twenty-one year period, except in 1970 (2.1523) and 1975 (2.1472) when it increased abnormally. No steady increase or decrease is recorded. The trend indicated by index of $\frac{\text{Output}}{\text{input}}$ is declining, since the indices show increase or decrease as compared to 1955.

I_t Index :

Kendrick's measure of total productivity (I_t Index) taking 1955 as base year shows an increasing trend in total productivity except for the years 1956, 1957, 1960, 1961, 1962 and 1973. Thus, as compared to the base year, the total productivity of labour and capital has increased.

Value Added as percentage of Output:

If absolute value added by factors is compared with the value of output, then it would indicate increase in productivity. If the net value added (the difference between output and inputs) increases, it implies that contribution of factors increase, since the output, input and value added are calculated at base year prices. Hence, the value added as percentage of output has been calculated to measure total productivity. The percentage has been fluctuating from year to year. Only in 1956, it was 56 per cent of the output.

Inputs as Percentage of Value Added:

Inputs as percentage of value added has been calculated in order to know the trends in the value of inputs required to generate value added, throughout the period. The percentage should be as low as posible in order to increase productivity. It was lowest during 1970 which indicates that total productivity was highest during 1970. This is also supported by labour productivity $\left(\frac{V}{L}\right)$ and capital productivity $\left(\frac{V}{K'}\right)$.

However, on the whole, the trend is fluctuating.

Inputs requirements per Tonne.

Inputs required per tonne of output also indicates level of productivity. The lower the value of inputs per tonne, the higher would be the productivity. Once again, 1970 shows the lowest value of inputs, hence, total productivity was the highest during this year (Table 4).

Inputs plus Wages and Salaries cost per Tonne:

Total cost per tonne is also an indicator of total productivity. Total cost has been calculated as the cost of inputs including depreciation and total payments made for wages and salaries. Rising costs per tonne-indicates that productivity is decreasing and *vice-versa*. The data reveal fluctuating performance but the trend is declining. It was at a fairly low level in 1970 (35.74), but

Table 3

Productivity Ratios (at 1951-52 prices)

Period	Output/Input	Indices of Output/Input	It Index	Value Added as percentage of Gross Output
1955	1.9034	100.00	100.00	50.90
1956	1.1206	58.87	13.83	6.38
1957	1.7997	94.53	82.34	37.10
1958	1.8337	96.33	119.80	41.76
1959	1.6479	86.57	108.79	40.82
1960	1.4113	74.14	88.22	32.60
1961	1.4466	76.00	96.49	33.94
1962	1.2541	65.88	83.38	27.85
1963	1.5624	82.08	129.58	42.41
1964	1.8077	94.97	146.73	46.98
1965	1.8405	96.69	143.75	44.11
1966	1.8200	95.61	166.96	49.57
1967	1.8221	96.04	163.96	45.88
1968	1.9026	99.95	157.35	45.97
1-4-69 to 31-3-70	2.1523	113.07	229.60	55.53
1971	1.8261	95.93	115.65	47.66
1972	1.5471	81.28	155.26	33.32
1973	1.4976	78.68	95.99	21.42
1974	1.9494	102.41	420.21	31.39
1975	2.1472	112.80	760.23	43.84

was lowest in 1975 (34.70). Thus, total productivity over the period has witnessed a rising trend.

Conclusion

On the basis of the above analysis, the following conclusions emerge :

(1) Labour productivity has shown an abrupt increase in 1957 followed by a fluctuating trend during 1958-68. It was highest during 1970.

(2) Capital productivity $\left(\frac{V}{K'}\right)$ and rate of return (r) on capital have exhibited rising trends, though, they were subject to many fluctuations.

(3) Real wages per worker taking 1951 as base year has increased over the period.

(4) Although, the number of workers has increased, labour requirements per

Table 4

Productivity Ratios (at 1951-52 prices)

Period	Inputs as percentage of value Added	Total Inputs / Total Tonnes Produced	Input+Wages and salaries / Total Tonnes produced
		Rs.	Rs.
1955	103.21	37.30	49.29
1956	1397.04	49.97	57.15
1957	149.74	31.11	38.10
1958	130.56	30.53	38.90
1959	148.64	33.78	41.47
1960	217.32	39.67	46.64
1961	203.63	38.71	45.26
1962	286.22	44.65	52.15
1963	150.88	35.83	42.41
1964	117.74	30.97	39.37
1965	123.17	30.42	37.70
1966	110.84	30.76	38.68
1967	119.20	30.63	38.17
1968	114.31	29.43	37.49
1-4-69 to 31-3-1970	83.66	26.01	35.74
31-3-71	114.88	30.66	39.52
31-3-72	193.97	36.19	45.62
31-3-73	311.59	37.39	46.10
31-3-74	163.39	28.72	37.89
31-3-75	106.22	26.58	34.70

tonne has decreased. This may be due to the increased production and increased capital intensity.

(5) Fixed net adjusted capital per worker has increased during the period. This shows that technological progress is capital absorbing.

(6) Total cost per tonne measured in terms of costs of inputs and wages and salaries has witnessed a declining trend.

(7) When we analyse all ratios, total productivity has increased over the period though it has shown many fluctuations. The performance of the unit was the best during 1970. The overall trend in productivity is increasing. □

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1. GENERAL

A. BOOKS

ARNFIELD R V Ed : Technological forecasting. Edinburgh, Edinburgh Univ. Press, 1969.

AYRES R U : Technological forecasting and long range planning. New York, McGraw Hill, 1969.

BEHRMAN D : Forecaster's forecast for the year 2000. *Unesco Features* No. 644, 1972.

BLOHM H, STEINBUCH K : *Technological forecasting in practice.* London, Saxon House, 1973.

BRIGHT J R : *Brief introduction to technological forecasting—concepts and exercises.* 3rd ed. Texas, Pemaquid Press, 1974.

Technological forecasting for industry and government—methods and applications. Englewood Cliffs, N. J., Prentice-Hall, 1968.

————— : *Working outline introduction to technological forecasting. Environmental forecasting conference.* University of Texas, Austin, January, 19-23, 1976.

BRIGHT J R, SCHOEMAN M E F *Eds. : Guide to practical technological forecasting.* Englewood Cliffs, N. J., Prentice-Hall, 1973.

CETRON M J ; *Technological forecasting—a practical approach.* New York, Gorden & Breach Science Publishers,1969.

CETRON M J, GOLDHAR J D *Ed : Science of managing organized technology*, New York, Gordon & Breach, 1970. 4 vol.

CHACKO G K : *Technological forecontrol—prospects, problems, and policy—managing today's technology for tomorrow's living.* Amsterdam, North Holland, 1975.

CHAMBERS J C & OTHERS : *Executive's guide to forecasting.* NY, Wiley Interscience, 1974.

CLARKE A C · *Profiles of the future—an inquiry into the limits of the possible.* NY, Harper & Row, 1973.

COLE S : *Technological forecasting and problems of dependency—some questions relevant to the outcome of the present materials crisis.* Background paper prepared for the UNDP/UNCTAD Expert group on shifts in Technological and Economic structures, 22-27th April, 1974.

COUTIE G A & OTHERS : *Short term forecasting.* Edinburgh, Oliver & Boyd, 1964.

DEACON J E : *"Bibliography on technological forecasting, technology assessment, future studies and long range planning"*, Plans report 74-1, Defence Research Board, Ottawa, Ontario, October 1974.

DOLMAN A J Ed : *Reshaping the international order—a report to the Club of Rome.* London, Hitchinson & Co., 1976.

EARL V : *Technological forecasting.* London, Economist Newspaper, 1968.

EMERY F & OTHERS : *Futures we are in,* Canberra, Centre. for Continuing Education, Australian National University, 1975.

EZEKIEL H : *Second India Studies—overview.* London, Macmillan 1978.

FERKISS V : *Future of technological civilization.* NY, 1974.

GREAVES W : *Technological forecasting in practice.* London, Industrial and Commercial Techniques, 1974.

HEIDE C : *Bibliography on technological forecasting and long-range planning.* Plans Report, 69-1, Defence Research Board, Ottawa, Ontario, 1969.

Introduction to various dimensions of technological forecasting—UN Economic Commission for Europe, Seminar on Technological Forecasting, Warsaw, 1970, Science/and Technology Working Paper 2.

JANTSCH E: *Technological forecasting in perspective*, Paris, OECD, 1967.

————*Technological Planning and social futures.* London, Cassell, 1972.

JAPAN SOCIETY OF FUTUROLOGY : *Challenges from the future-proceedings of the International Future Research Conference.* Japan, Kodansha Ltd. 1970.

JAPAN TECHNOECONOMICS SOCIETY : *Science and technology development upto 2000AD.* Tokyo, The Society, 1972.

LEIN A P & OTHERS : *Technological forecasting-tools, techniques and applications.* AMA Management Bulletin No. 115, 1968.

LENZ R C : *Technological forecasting*. Clearinghouse AD 408085, Springfield, Va., 1962.

LINSTONE H A, SIMMONDS W H C *Eds : Futures research-new directions.* Reading Mass., Addison-Wesley Publishing Co. 1977.

MAKINO N : *Introduction to technological forecasting.* Tokyo, Nikkam Kogyo. Newspaper Co., 1970.

MARTINO J P : *Technological forecasting for decision making.* Newyork, American Elsevier Publishing Co., 1972.

MENDLOVITZ S H *Ed : On the creation of a just world order-preferred worlds for the 1990's.* Delhi, Orient Longmann, 1975.

MESAROVIC M, PESTEL E : *Mankind at the turning point—the second report of the Club of Rome.* Newyork, EP Dutton Co., 1974.

MESAROVIC M D & OTHERS : *Theory of hierarchical multilevel systems.* New York, Academic Press, 1970.

ORNAUER H & OTHERS *Eds : Images of the world in the year 2000—a comparative ten nation study.* Highlands, Humanities Press, 1976.

POLAK F L : *Image of the future.* Amsterdam, Elsevier Scientific Publishing Co , 1973.

————; *Prognostics—a science in the making surveys and creates the future.* Amsterdam, Elsevier Publishing Co. 1969.

PREHODA R W : *Designing the future—the role of technological forecasting.* Philadelphia, Chilton Book Co. 1967.

ROHATGI P K & OTHERS : *Technological forecasting.* New Delhi, Tata McGraw-Hill, 1979.

ROHATGI P K, BOWONDER B : *Technological forecasting as applied to Indian environment.* Proceedings of IEEE Annual Meeting, Bombay, Jan 1974.

ROSLANSKY J D Ed : *Sharping the future—a discussion at the nobel conference.* Amsterdam, North Holland Pub. Co., 1972.

SWAGER W L : *Summary of technological forecasting seminar,* Battelle Seattle Research Center, Nov. 5-7, 1969.

TOFFLER A : *Future shock.* London, Bodley Head, 1970.

————*Futurists.* NY, Random House, 1972.

WALL STREET JOURNAL *: Here comes tomorrow—living and working in the year 2000.* New Jersey, Dow Jones Books, 1967.

WILIAMS J C, WILLS G : *Forecast of numerical control technologies* Palry 12, 1968.

B. ARTICLES :

BLACKMAN A W : New venture planning—the role of technological forecasting. *Technological Forecasting & Social Change* 1973, 5(1), 25-49.

BOWONDER B, ROHATGI P K : Technological forecasting—applicability, relevance and future crisis—analysis in a developing country. *Technological Forecasting and Social Change* 1975, 7, 233-56.

BRIGHT J R : Can we forecast technology ? *Management Thinking* 1968, July 12-15.

————: Technology forecasting—new tools for an old responsibility *Research Management* 1972, 15(4), 50-65.

BUSCHMANN R : Balanced grand scale forecasting *Technological Forecasting* 1969, 1, 221-3

CETRON M J : Forecasting Technology *International Science and Technology* 1967, 69 (September), 85-92.

————: Technological forecasting—practical problems and pitfalls *IEEE Transactions on Engineering Management* 1969, 115-41.

————: Using technological forecasts *Science and Technology* 1968, 79(July), 57-63.

DOBROV G M : Scientific-technological forecasting in the U.S.S.R. *Long Range Planning* 1971, 3(3), 13-21.

DORY J P : Does TF really work ? *Harvard Business Review* 1970, 48(6), 16-18.

FRIED J, MOLNAR P : General model for culture and technology *Technological Forecasting & Social Change* 1975, 8, 175-88.

GERSTENFELD A : Technological Forecasting *Journal of Business* 1971, 44(1), 10-17.

GOLDFARB A J : Technological forecasting—what and whither? *Technological Forecasting & Social Change* 1971, 3, 51-64.

HELMER O : Problems in futures research *Futures* 1977, 9(1) 17-31.

HOOS I R : Criteria for good futures research *Technological Forecasting & Social Change* 1974, 6, 113-32.

————————: Some fallacies in futures research *Technological Forecasting & Social Change* 1977, 10(4), 335-44.

ISENSON R S : Technological forecasting—a management tool *Business Horizons* 1967, 10(1), 37-46.

————————: Technological forecasting in perspective *Management Science* 1966, 13(2), B70-B83.

KHOL R : What good is technological forecasting ? *Management Review* 1973, 62(3), 51-4.

KIEFER D M : Industry maps tomorrow's technology *Chemical Engineering News* 1972, February, 111-119.

LANFORD H W : Problems in the teaching of technological forecasting *Technological Forecasting* 1970, 1, 421-6.

————————: Technological forecasting jungle *Technological Forecasting & Social Change* 1972, 4, 207-25.

LOVEWELL P J, BRUCE R D : How we predict technological change *New Scientists* 1962, 13(274), 370-73.

MARTINO J P : Computers and technological forecasting *Futurist* 1971, 5, October 205-6.

MARTINO J P : Forecasting technological breakthrough *Futurist* 1970, 4(January), 21-27.

————————: New approach to technological forecasting 1970, 17-23.

MENDEL J S : Technological forecasting-the state of the art *Futurist* 1969, 160-65.

MEYER F, VALLEE J : Dynamics of long term growth *Technological Forecasting & Social Change* 1975, 7, 285-300.

MITROFF I I, TUROFF M : Technological Forecasting & assessment-science and/or mythology ? *Technological Forecasting & Social Change* 1973, 5, 113-34.

OLENZAK A T:Technological forecasting—a pragmatic approach *Chemical Engineering Progress*—1972, June, 27-32.

PORTER A L, ROSSINI F A : Evaluation designs for technology assessments and forecasts *Technological Forecasting & Social Change* 1977, 10(4), 369-80.

PYKE D K : Technological forecasting—a framework for consideration *Futures* 1970, 2, 327.

QUINN J B. : Technological forecasting *Harvard Business Review* 1967, 45(2), 89-106.

RHYNE R : Technological forecasting within alternative whole future projections *Technological Forecasting & Social Change* 1974, 6, 133-62.

SARDANA P K : "Technological forecasting—a snapshot". *Lok Udyog*, 1973, 7(6), 35-40.

SINGH M : Theory & practice of technological forecasting *Journal of Scientific & Industrial Research* 1975, 34(11), 5 93-6.

STARR C, RUDMAN R : Parameters of technological growth *Science* 26 Oct , 1973, p. 358-64.

VOGEL P H : Basis for technological forecasting *Technological Forecasting* 1970, 1, 313-23.

WILLS G : Preparation and deployment of technological forecasts *Long Range Planning* 1970, 2(3), 44-52.

WISE G : Accuracy of technological forecasts 1890-1940 *Futures* 1976, 8(5), 411-19.

2. METHODOLOGY

A. BOOKS

BAYNE C D, PRICE W : *Technological forecasting questionnaire* Boston Mass, Harvard Business School, 1971.

BREWER G D : *Gaming—perspective for forecasting.* Santa Monica, Rand Corporation, 1974.

BROWN B & OTHERS · *Delphi method II—structure of experiments.* Santa Monica, Rand Corporation, 1969.

BROWN B, HELMER O : *Improving the reliability of estimates, obtained from a consensus of experts.* Santa Monica, Rand Corporation, 1964.

CLARK J & OTHERS : *Global simulation models—a comparative study.* London, John Wiley & Sons, 1975.

CLAYTON R : *Technology forecasting and assessment - a methodology review*, working paper, Ministry of State for Science and Technology, Ottawa, Ontario, August 1974.

COLE H S D & OTHERS · *Thinking about the future—a critique of the limits to Growth.* London, Sussex University. Press, 1973. (Published in USA as Models of doom—a critique of the limits to growth).

CONSAD RESEARCH CORPORATION : *Transit usage forecasting techniques—a review and new directions.* Pittsburgh, Penn, the Corporation, 1968.

DALKEY N C : *Delphi* Santa Monica, Rand Corporation, 1967.

————: *Elementary cross impact model.* Santa Monica, Rand Corpn. 1971.

————: *Predicting the future.* Santa Monica, Rand Corporation, 1968.

DALKEY N C, ROURKE D L : *Experimental assessment of delphi procedures with group value judgements.* Santa Monica, Rand Corporation 1971.

De JOUVENEL B : *Art of conjecture.* London, Weidefeild & Nicolson, 1967.

DELEECQ AL & OTHERS : *Group techniques for programme planning—a guide to nominal group and delphi processes.* Glenview, Ill, Scott, Forman & Co., 1975.

DUVAL A & OTHERS : *Cross—impact—a handbook on concepts and applications.* Battelle, Geneva, 1974.

ENCEL S & OTHERS : *Eds. : Art of anticipation—values and methods in forecasting.* Sussex, Science policy research Unit, University of Sussex, 1975.

ENZER S : *Delphi and cross impact techniques—an effective combination for systematic futures analysis.* Institute for the Future, 1970.

FOLK M : *Critical look at the cross impact matrix method,* Syracuse, NY, Educational Policy Research Centre, 1971.

FORRESTER J W : *World dynamics,* Cambridge. Wright-Allen Press, 1971.

FOSTER R & OTHERS *Scenario generating methodology.* Cambridge, Art Associates, 1970.

FREEMAN C, JAHODA M *Eds. : World futures—the great debate.* London, Martin Robertson, 1978.

GORDON T J, HELMER O : *Report on a long range forecasting study.* Santa Monica, Rand Corporation, 1964.

GORDON T J & OTHERS : *Research on cross impact techniques with applications to selected problems in economics, political science, and technology assessment.* Middletown, Conm, Institute for the Future, 1970.

HERRERA A O & OTHERS : *Catastrophe or new Society ?—a Latin American world model.* Ottawa, International Development Research Centre, 1976.

HUDSON L : *Uses of cross impact matrix in exploring alternatives for the future.* Syracuse, NY, Educational Policy Research Centre, 1969.

LANFORD H W : *Technological forecasting methodologies—a synthesis.* NY, AMA, 1972.

LENZ R C Jr : *Development of explicit methods in technological forecasting.* Unpublished Master's thesis, MIT., Cambridge, Massachusetts, 1959.

LINSTONE H A, TUROFF M *Eds. Delphi methods—techniques and applications.* Reading, Massachusetts, Addison-Wesley, 1975.

LINSTONE H A, SAHAL D *Eds : technological substitution—forecasting techniques and applications.* NY, Elsevier, 1976.

MEADOWS D L *Ed : Alternatives to growth—a search for sustainable futures.* Cambridge, Mass, Ballinger Pub. Co., 1975.

MEADOWS D H & OTHERS : *Limits to growth—a report for the Club of Rome's project on the predicament of mankind.* 2nd ed. New York, Universe Books, 1974.

MEADOWS D L & OTHERS : *Dynamics of growth in a finite world.* Massachusetts, Wright-Allen Press, 1974.

MEADOWS D L, MEADOWS D H : *Toward global equilibrium-collected papers,* Massachusetts, Wright-Allen Press, 1974.

MILES I : *Poverty of prediction.* Westmead, England, Saxon House, 1975.

PARIKH K S : *Second India and Energy.* Macmillan, 1976.

PEPPARD L E, BEAL J C : *Multidisciplinary approach to the modelling of a socio-economic system.* Kingston, Ontario, Canada, Dept. of Electrical Engineering, Queens University, 1965.

PILL J : *Delphi method—substance context, a critique and an annotated bibliography,* Case Western Reserve University School of Management, 1970.

RESCHER N : *Delphi and values.* Santa Monica, Rand Corpn. 1969.

ROCHBERG R & OTHERS : *Use of cross impact matrices for forecasting and planning.* Institute for the Future, April 1970.

ROONEY J W : *Survey and critique of technological forecasting methods.* Virginia, NTIS, 1971.

ROSE N . *Survey and preliminary assessment of technological forecasting and planning methodologies.* Hudson Institute, 1970.

SACKMAN H : *Delphi assesment—expert opinion, forecasting, and group process.* Santa Monica, Rand Corpn., 1974.

———————— : *Delphi critique—expert opinion forecasting and group process.* Laxington, Luxington Books, 1975.

STANFORD RESEARCH INSTITUTE : CENTRE FOR THE STUDY OF SOCIAL POLICY : *Handbook of forecasting techniques.* Springfield, National Technical Information Service, 1975.

SWEEZE E E : *Technological forecasting– principles and techniques.* Paper presented at the 4th symposium of the Engineering Economy Division, American Society for Engineering Education, Chicago, Ill., June 1965.

WELTY G : *Critique of the Delphi technique.* American Statistical Association, Proceedings, 1972.

WHEELWRIGHT S C, MAKRIDAKIS S : *Forecasting methods for management 2nd Ed.* My, Inter-science, 1977.

2. ARTICLES

ABT C C : Approach to method of combined sociotechnological forecasting *Technological Forecasting Social Change* 1970, 2, 17-22

AISO M : Forecasting techniques/*IBM Systems Journal* 1973, 12(2), 187-209.

ALBERTSON L : Delphi and the image of the future *Futures* 1976, 8(5), 397-404.

ALDERSON R C, SPROULL W C : Requirement analysis, need forecasting, and technology planning using the Honeywell PATTERN technique *Technological Forecasting and Social Change* 1972, 3(2), 255-65.

AMARA R C, LIPINSKI A J : Some views on the use of expert judgement *Technological Forecasting and Social Change* 1972, 3(3), 279-89.

AMENT R G : Comparison of delphi forecasting studies in 1964 and 1969 *Futures* 1970, March, 35-44.

AYRES R U, SHAPANKA A : Use of explicit technological forecasts in long range input-output models *Technological Forecasting & Social Change* 1976, 9(1-2), 113-38.

BLACKMAN A W : Cross impact model applicable to forecasts for long-range planning/*Technological Forecasting & Social Change* 1973, 5, 233-42.

———— : Forecasting through dynamic modelling *Technological Forecasting & Social Change* 1972, 3, 291-307.

BLACKMAN A W : Market dynamics of technological substitutions *Technological Forecasting & Social Change* 1974, 6, 41-63.

———— : Mathematical model for trend forecasts *Technological Forecasting & Social Change* 1972, 3, 441-52.

———— : Normex forecasting of jet engine characteristics *Technological Forecasting & Social Change* 1970, 2, 61-76.

———— : Use of Bayesian techniques in delphi forecasts *Technological Forecasting & Social Change* 1970, 2(3-4), 261-68.

———— : Use of dynamic modelling for conditional forecasts of resource allocation policies *Technological Forecasting & Social Change* 1974, 6, 191-208.

———— : Innovation index based on factor analysis *Technological Forecasting & Social Change* 1973, 4, 301-16.

BLOOM M F : Deterministic trend cross-impact forecasting *Technological Forecasting & Social Change* 1975, 8(1), 35-74

———— : Time-dependent event cross-impact analysis-results from a new model *Technological Forecasting & Social Change* 1977, 10(2), 181-201.

BRATT B C · Methodology in long range forecasting. *Commercial and Financial Chronicle* 1960, Feb, 10-11.

BRIGHT J R : Few kind words for extrapolation *Futures* 1973, 5(4), 344-5.

———— : Evaluating signals of technological change *Harvard Business Review* 1970, 48(1), 62-70.

CARTER A P · Technological forecasting and input-output analysis *Technological Forecasting* 1970, 1(4), 331-45.

CETRON M J, CLAYTON A : Social forecasting—a practical approach *Technological Forecasting & Social Change* 1975, 7(4), 339-55.

CHAMBERS J C : How to choose the right forecasting technique? *Harvard Business Review* 1971, 49(4), 45-74.

CHAPMAN P F : Method for exploring the future *Long Range Planning* 1976, 9(1), 2-11.

CHEN K : On the choice and linkage of large scale forecasting models *Technological Forecasting & Social Change* 1976, 9(1-2), 27-33.

CIMA F & OTHERS : Forecasting model for the market of competitive products *Technological Forecasting & Social Change* 1973, 5, 51-65.

COATES J F : Some methods and techniques for comprehensive impact assessment *Technological Forecasting & Social Change* 1974, 6, 341-57.

COLE S : World models—their progress and applicability *Futures* 1974, 6, 201-18.

COLE S & OTHERS : Scenarios of world development *Futures* 1978, 10(1), 3-20.

DALKEY N C : Elementary cross-impact model *Technological Forecasting & Social Change* 1972, 3, 341-51.

DALKEY N C, HELMER O : Experimental application of the delphi method to the use of experts *Management Science* 1963, 9, 458-67.

DODSON E M : General approach to measurement of the state-of-the art and technological advance *Technological Forecasting* 1970, 1, 391-408.

DRESSLER F R S : Subjective methodology in forecasting *Technological Forecasting & Social Change* 1972, 3, 427-39.

DUPERIN J C, GODET M : SMIC 74-a method for constructing and ranking scenarios *Futures* 1975, 7(4), 302-12.

ENZER S : Cross impact techniques in technology assessment *Futures* 1972, 3(1), 30-51.

———— : Delphi and cross impact techniques *Futures* 1971, 3, 48-61.

ESTES G M, KNESPERT D : Delphi in industrial forecasting *Chemical Engineer News* 1976, (Aug. 23), 40-7.

EYMARD J : A Markovian cross-impact model *Futures* 1977, 9(3), 216-28.

FEIN E : Projecting from current data *Technological Forecasting & Social Change* 1973, 5, 91-3.

FISHER J C, PRY R H : Simple substitution model of technological change *Technological Forecasting & Social Change* 1971, 3(1). 75-88.

FISHER M : Toward a mathematical theory of relevance trees *Technological Forecasting* 1970, 1, 381-9.

FRANCO G R : Selecting efficient forecasts *Futures* 1973, 5(4), 383-91.

FUSFELD A R : Technological progress function—a new technique for forecasting. *Technological Forecasting* 1970, 1, 301-12.

FUSFELD A R, FOSTER R N : Delphi technique—survey and comment *Business Horizons* 1971, 4, 63-74,

GAPPERT G : Development of a PATTERN model for social forecasting *Futures* 1973, 5(4), 367-82.

GORDON T J, HAYWARD H : Initial experiments with the cross impact matrix methods of forecasting *Futures* 1969, 1(2), 100-16.

HELMER O : Cross impact gaming *Futures* 1972, 3(2), 149-67.

HILL K Q, FOWLES J : Methodological worth of the delphi forecasting technique *Technological Forecasting & Social Change* 1975, 7, 179-92.

HOPKINS F S : Limitations of world system models *Futurist* 1975, 9(5), 258-62.

HRUSKA A : Science forecasting and its limits *Futures* 1974, 6(2), 153-60.

HUCKFELDT V E, JUDD R C : Issues in large scale delphi studies *Technological Forecasting & Social Change* 1974, 6, 75-88.

JACKSON J E, LAWTON W H : Some probability problems associated with cross impact analysis *Technological Forecasting & Social Change* 1976, 8, 263-73.

JANTSCH E : Toward a methodology for systematic forecasting *Technological Forecasting* 1970, 1, 409-19.

HURTER A P, RUBENSTEIN A H : Market penetration by new innovations—the technological literature *Technological Forecasting & Social Change* 1978, 11(3), 197-221.

JONES H : Morphology and creativity in technological forecasting *R & D Management* 1976, 6(3), 125-130.

———— : Systematic approach to technological forecasting *R & D Management* 1976, 6(1), 23-30.

KANE J : Primer for a new cross impact language KSIM *Technological Forecasting & Social Change* 1972, 4, 129-42.

KENDALL J W : Variations of delphi *Technological Forecasting & Social Change* 1977, 11, 75-85.

KOVAC F J, DAGUE M F : Forecasting by product life cycle analysis *Research Management* 1972, 15(4), 66-72.

LANDFORD H W, ROSS C B : Applying the envelop curve to technological forecasting and long range planning—the evolution of the lasser. *Industrial Marketing Management* 1975, 4(1), 1-8.

LECLERCQ R : Use of generlaized logic in forecasting *Technological Forecasting* 1970, 2, 189-94.

LENZ R C, LANFORD H W : Substitution phenomenon *Business Horizons* 1972, 15(1), 63-8.

———— : Trend extrapolation—workhorse of technological forecasting *Industrial Marketing Management*, 1973, 3(1), 58-65/8f/

LISICHKIN V A : Process of making forecasts *Technological Forecasting*, 1969, 1, 97-104.

MARTIN W T, SHARP J M : Reverse factor analysis - a modification of relevance tree techniques *Technological Forecasting & Social Change* 1973, 4, 355-73.

MARTINO J P : Correlation of technological trends *Technological Forecasting* 1970, 1, 347-54.

———— : Effect of errors in estimating the upper limit of a growth curve *Technological Forecasting & Social Change* 1972, 4, 77-84.

———— : An experiment with the delphi procedure for long range forecasting *IEEE Transactions on Engineering Management* 1968, EM. 15, 138-44.

———— : Precision of delphi estimates *Technological Forecasting* 1970, 1(3), 293-99.

MARTINO J P, CHEN K : Clusta analysis of cross-impact model scenarios *Technological Forecasting & Social Change* 1978, 12(1), 61-71.

MITCHELL R B & OTHERS : Scenario generation—limitations and developments in cross-impact analysis *Futures* 1977, 9(3), 205-15.

MITCHELL R B, TYDEMAN J : Subjective conditional probability modelling *Technological Forecasting & Social Change* 1978, 11(2), 133-52.

MITROFF I I, TUROFF M : On measuring the conceptical errors in large scale social experiments—the future as decision *Technological Forecasting & Sccial Change* 1974, 6, 389-402.

MITROFF I I, TUROFF M : On the distance between cross impact models—a set of metric measures for cross impact analysis *Technological Forecasting & Social Change* 1976, 8, 275-82.

NOVICK D, PARDEE F S : Reducing lead time through improved technological forecasting—some specific suggestions for more usefully formulated projections of technological availability *Technological Forecasting* 1969, 1, 141-50.

NUTT A B : Data sources for trend extrapolation in technological forecasting *Long Range Planning* 1976, 9(1), 72-6.

O'NEAL C R : Morphological analysis—an integrative approach *Business Horizons* 1970, 13(6), 47-58.

PYKE D L : Mapping—a system concept for displaying alternatives *Technological Forecasting & Social Change* 1971, 2, 311-20.

PILL J : DELPHI method—substance, contexts, a critique and an annotated bibliography *Socio-Economic Planning Sciences* 1971, 5, 57-71.

PYKE D L : Practical approach to DELPHI *Futures* 1970, 2, 143-52.

RIBEILL G : Elements and methods of industrial forecasting *Futures* 1974, 6(5), 395-403.

ROBERTS E B : Exploratory and normative technological forecasting—a critical appraisal *Technological Forecasting* 1969, 1, 113-27.

ROCHBERG R : Information theory, cross impact matrices, and pivotal events *Technological Forecasting & Social Change* 1970, 2, 53-60.

ROUSE W B, SHERIDAN T B : Computer aided group decision making—theory and practice *Technological Forecasting and Social Change* 1975, 7, 113-26.

ROWLANDS D G : Technological forecasting and the DELPHI technique—a reply *Long Ragne Planning* 1969, 2(2), 78-9.

SAHAL D : Generalized distance measures of technology *Technological Forecasting & Social Change* 1975, 7(1), 81-97.

————: Generalized logistic model of technological forecasting *Technological Forecasting & Social Change* 1975, 7(1), 81-97.

————: Generalized Poisson and related models of technological innovation *Technological Forecasting & Social Change* 1974, 6, 403-36.

————: Special analytic study of some postulates concerning engineering design and related processes *Technological Forecasting & Social Change* 1976, 8, 285-308.

SAHAL D, YEE K : DELPHI—an investigation from a Bayesian viewpoint *Technological Forecasting & Social Change* 1975, 7, 165-78.

SALANCIK J R : Assimilation of aggregated inputs into DELPHI forecasts—a regression analysis *Technological Forecasting & Social Change* 1973, 5, 243-7.

SALANCIK J R & OTHERS : Construction of DELPHI event statements *Technological Forecasting & Social Change* 1971, 3(1), 65-73.

SARDANA P K & OTHERS : Technological Forecasting—through scenario construction *Lok Udyog* 1974, 8(6), 49-53.

SHARIF M N, KABIR C : Generalized model for forecasting technological substitution *Technological Forecasting & Social Change* 1976, 8(4), 353-64.

————: System dynamics modelling for forecasting multilevel technological substitution *Technological Forecasting & Social Change* 1976, 9(1-2), 89-112.

SHARIF M N, UDDIN G A : Procedure for adapting technological forecasting models *Technological Forecasting & Social Change* 1975, 7, 99-106.

SHARIF M N, WAI-HING CHIN ; Stochastic network technique for technological forecasting *Technological Forecasting & Social Change* 1977, 10(3), 259-76.

STAPLETON E : Normal distribution as a model of technological substitution *Technological Forecasting & Social Change* 1976, 8(3), 325-34.

STERN M O & OTHERS : Model for forecasting the substitution of one technology for another *Technological Forecasting & Social Change* 1975, 7, 57-79.

STOVER J : Suggested improvements to the DELPHI/Cross-impact technique *Futures* 1973, 5(3), 308-13.

SULC O : Interactions between technological and social changes—a forecasting model *Futures* 1969, 402-407.

————: Methodological approach to the integration of technological and social forecasts *Technological Forecasting* 1969, 1, 105-8.

TUROFF M : Alternative approach to cross impact analysis *Technological Forecasting & Social Change* 1972, 2, 309-39.

VALASKAKIS K : Eclectics paradigm—a proposed methodology for futures studies *Futures* 1975, 7(6), 451-62.

VANSTON., J H & OTHERS : Alternate scenario planning *Technological Forecasting & Social Change* 1977, 10(2), 159-80.

——— ——— : PAF—a new probabilistic, computer-based technique for technology forecasting *Technological Forecasting & Social Change* 1977, 10(3), 239-58.

VOYER R D : DELPHI technique—a valuable tool for technological forecasting *Science Forum* 1969, 2(5), 6-8.

WAKE LAND W : QSIM 2—a low-budget heuristic approach to modeling and forecasting *Technological Forecasting & Social Change* 1976, 9, 213-29.

WILMOT P D : Comparison of the methods of technological forecasting *Industrial Marketing Management* 1971, (1), 95-192.

WOODEN R P: Technological forecasting the DELPHI technique *Food Technology* 1971, 25(Oct), 1033-7.

YELLE L E : Technological forecasting—a learning curve approach *Industrial Management (USA)* 1974, 16(1), 6-11.

ZEMAN M : Remarks on teratological forecasting models *Technological Forecasting & Social Change* 1974, 6, 209-17.

ZENTNER R D : Scenario in Forecasting *Chemical & Engineering News* 1975, 6(10), 22-34.

3. APPLICATIONS

A. BOOKS

ABT ASSOCIATES : *Integrated techonological forecasting and R & D planning system* Cambridge, Abt Associates, 1970.

AGARWAL S N : *Long range planning and Technological forecasting for food processing industries.* Project Report submitted in partial fulfilment of the Post-Graduate Diploma in Industrial Management, Indian Institute of Sciences, Bangalore, 1974.

AMBANNAVAR J P : *Population—second India Studies,* New Delhi, Macmillan, 1975.

BARAN, P, LIPINSKI A J : *Future of the telephone industry 1970-1985.* Institute for the Future, 1971.

BECKER H S : *Method of obtaining forecasts for long-range aerospace program planning.* Institute for the Future, 1970.

BEHARI B : *Economic growth and technological change.* Bombay, Vikas, 1974.

BELL D Ed : *Toward the year 2000.* Boston, Beacon Press, 1967.

BOWONDER B : *India 2000 AD.* Centre for Policy Studies, IIT, Madras, 1976.

BROWN O W, BURKHARDT J L : *Computer memory market—an example of the application of technological forecasting in business planning,* Paper presented at the second session of the Second Annual Technological Forecasting Conference, Lake Placid, NY, June 9-13, 1968.

BURGESS T & OTHERS : *Manpower and education development in India 1961-86.* London, Oliver & Bayd 1968.

CALDER N Ed : *World in 1984.* Middlesex, Penguin Books, Ltd. 1965.

CALIFORNIA UNIVERSITY, SCHOOL OF PUBLIC HEALTH : *DELPHI forecasting of health care organisations.* Berkeley 1973.

CETRON M J, RALPH C A : *Industrial applications of technological forecasting—its utilization in R & D management,* NY, Wiley-Interscience 1971.

CONFERENCE BOARD : *Perspectives for the 70's and 80's. tomorrow's problems confronting today's management,* NY The Board, 1970.

CURRILL D L : *Implications of technological forecasting for research and development.* Research Report, Management Centre, University of Bradford, June 1970.

DEBRIGARD R, HELMER O : *Some potential societal developments 1970-2000.* Middle Town, Conn., Institute for the Future, 1970.

De HOGHTON C & Others; *And now the future—a PEP survey of futures studies.* London, PEP, 1970.

EMERY FE, TRIST E L : *Towards a social ecology-contextual appreciation of the future in the present.* London, Plenum Press, 1973.

GORDON T J, AMENT RG : *Forecasts of some technological and scientific developments and their societal consequences.* Connecticut, Institute for the Future, 1969.

HARRISON A : *Bibliography on automation and technological change and studies of the future.* Rand Corpn. May, 1967.

HARRISON D P : *Social forecasting methodology—suggestions for research.* NY, Russell Sage Foundation, 1976.

HARVARD BUSINESS REVIEW : *Forecasting series.* Boston, HBR Publications, 1971.

HAYDON B : *The year 2000.* Santa Monica, Rand Corpn., 1967.

HELMER O : *Future of science,* Santa Monica, Rand Corporation 1967.

——— ——— : *On the future state of the union.* California, Institute for the future 1972.

——— ——— : *Prospects of technological progress.* Santa Monica, Rand Corporation 1967.

HILL R L Ed : *America 1980.* Washington, US Department of Agriculture, 1965.

IYENGAR M S : *Methodology in relation to food forecastion.* Report of the NCST Panel, Government of India, 1976.

JAMES E: *Transportation of freighting the year 2000,* Great Lakes Area Trade Development Detroit, 1974.

JUNGK R : *Everyman project—resources for a human future.* London, Thames & Hudson, 1976.

KAHN H & OTHERS : *Next 200 years—a scenario for America and the world.* London, Associated Business Programmes Ltd., 1976.

KAHN H, BRUCE-BRIGGS B : *Things to come—thinking about the seventies and eighties.* NY, Macmillan 1972.

KAHN H, WIENER A J : *Year 2000—a framework for speculation on the next thirty three years.* London, *Macmillan Co.*, 1967.

KAPLAN A & OTHERS : *Prediction of social and technological events.* Santa Monica, Rand Corporation 1949.

KAPUR J C : *India in the year 2000.* Delhi, India International Centre, 1975.

KONONENKO A, POLYAK A : *Present and foreseeable trends in the development of tractors—especially high capacity tractors.* UN Economic & Social Council, 1971.

KRUZIC P G : *Cross impact simulation in water resource planning.* Menlo Park, California, Stanford Research Institute, 1974.

KUMAR V V, ROHATGI P K : *Evaluation of energy scenarios.* Report submitted to Tata Energy Research Industries, 1975.

MARTIN J : *Future development in telecommunications.* Englewood Cliffs, N. J., Prentice-Hall, 1971.

MEDVEDEV V F & OTHERS : *Forecasting methods as a basis for the long-range planning of scientific and technological development.* UNECE Seminar on Technological Forecasting. Warsaw 1970. Science and Technology Paper No. 22.

MULLER H J: *Uses of the future* London, Indana University Press, 1974.

NORTH H Q, : *Technological forecasting in Industry.* NATO Defence Research Group Conference, National Physical Laboratory, England, November 1968.

NORTH H Q, PYKE D L : *Probe of TRW's future.* TRW Internal Report July, 1966.

———————— : *Technological forecasting in planning for company growth* IEEE Spectrum, January, 1969.

————————: *Technological forecasting to aid R & D planning.* Proceedings of the 22nd National Conference on the Administration of Research, St. Charles, Ill,. September 1968, p. 59-69.

O'FLAHERTY C A : *Passenger transport present and future.* London, Leeds University Press, 1969.

PARDEE F S : *State of the art projecting and long range planning of applied research.* Santa Monica, Rand Corporation 1965.

———————— : *Technological projecting and advanced product planning.* Rand Corporation, 1967.

ROBINSON B E : *DELPHI forecast of technology in Education.* Bethesda, Maryland, ERIC. 1973.

SAUVY A : *Zero growth ?* Oxford, Bassil Blackwell, 1975.

SCHRIEVER B A, WILLIAMS W S : *Air transportation 1975 and beyond—a systems approach.* Cambridge, MIT Press, 1968.

SEARL M : *Energy modelling—art, science, practice.* Washington, DC., Resources for the Future Inc., 1973.

SHIRLEY INSTITUTE : *UK Textile industry in 1980—a technical forecast made using a modification of the DELPHI technique by* Res P. Rodgers. Manchester, Shirley Institute, 1972.

STANFORD RESEARCH INSTITUTE : *Future transportation systems—desired characteristics and futur transportating systems—technological assessment.* Menlo Park, Calif., Institute, 1967.

STARR C, SMITH C : *Energy of the world of 2000 AD.* Special report to the National Academy of Engineering (Sept. 1967).

STORMER P R : *Long range planning and technological forecasting—an anuotated bibliography.* Lockheed Missile & Space Co., 1963.

———————— *Long-range planning and technological forecasting—an annotated bibliography.* Sunnyvale, Calif., Lockheed Aircraft Corporation, 1965.

SWAGER W L: *Industrial implications of technological forecasting.* Paper presented to the 4th Symposium of the Economy Division of the American Society for Engineering Education. Chicago, Ill., 19 June 1965. Battelle Memorial Institute.

TATA ECONOMIC CONSULTANCY SERVICES : *Indian economy in 2000.* Bombay, 1974.

———————— : *Tertiary sector in Second India/Second India Studies.* Bombay 1975.

TOLKACHEV A S : *Forecasts of progress in science and technology and their application in long term economic planning,* Seminar on Technological Forecasting held at Warsaw 1970. UN Economic Commission for Europe. Science & Technology Working Paper No. 14.

UNESCO : *Asian model of education—perspective for 1965-80.* Paris, Unesco, 1976.

WEBER E & OTHERS : *Technology forecast for 1980.* NY, Van Nostrand Reinhold Co., 1971.

WILLIAMS R F, BJERRUM C A : *Forecast 1968-2000 of computer developments and applications.* Parsons & Williams, International Seminar on File Organizations. Copenhagen, Denmark, November 1968.

WILLS G : *Technological forecasting—the art and the managerial implications.* Middlesex, Penguin, 1972.

WILLS G & OTHERS : *Technological forecasting and corporate strategy.* London, Broadford University Press, 1969.

YOUNG M Ed : *Forecasting and the social sciences.* London, Heinemann, 1968.

B. ARTICLES

ANDERSON S L : Forecasting trends in wool research *Wool Science Review* 1973, 44(2).

ARDIN B H : Forecasting petrochemicals markets & prices *Processing* 1976, 22(5), 31-32.

AUJAC H : French experiment in long and very-long-term national technological forecasting. The basic role of semantics *Technological Forecasting & Social Change* 1972, 4(1), 23-35.

AUSTIN A L, BREWER J W : World population growth and related technical problems *Technological Forecasting & Social Change* 1971, 3, 23-49.

BARCH J L, TWERY R J : Forecasting techniques in R & D planning *Chemical Engineering Progress* 1970, June 15-19.

BENDER A D & OTHERS: DELPHI study examines developments in medicine *Futures* 1969, June, 289-303.

BERNSTEIN G B : NAVSUP's technological forecast program *Navy Supply Corporations Newsletter* 1968, 31(11), 34-3.

BERNSTEIN G B, CETRON M J : SEER—a DELPHIC approach applied to in formation processing *Technological Forecasting* 1969, 1, 33-54.

BJERRUM C A : Forecast of computer developments and applications, 1968-2000. *Futures* 1969, 1, 331-8.

BLACKMAN A W : Rate of innovation in the commercial air craft jet engine market *Technological Forecasting & Social Change* 1971, 269-76.

BOSSERT R W : Logistic growth curve reviewed, programmed, and applied to electric utility forecasting/*Technological Forecasting & Social Change* 1977, 10(4), 357-68.

BOULADON G : Aviations's role in the future transportation *Technological Forecasting* 1969, 1, 5-16.

———————— : Technological forecasting applied to transport *Futures* 1970, 2, 15.

BOWONDER B ; Technological forecasting and management of R & D *Chemical Age of India* 1977, 28(13), 39-46.

BOWONDER B, ROHATGI P K : Future energy of India—a DELPHI study *Energy Policy* 1976, 4(1), 69-73.

———————— : Future of steel technology in India *Journal of Scientific & Industrial Research* 1977, 36(8), 355-67.

BOWONDER B & OTHERS : Technology forecasting for aluminium industry in India *Journal of Scientific & Industrial Research* 1976, 35, 649-56.

BOWONDER B, ROHTAGI P K : Technological forecasting for planning research and production in chemical industries *Chemical Age of India* 1973, 24(9), 575-82.

BRAUN, CHRISTOPHE-FRIEDRICH von : Airships in the future —approaching the unknowns *Futures* 1975, 7(6), 475-84.

BROOKES L G : Forecasting as an aid to R & D decision making in the nuclear power field *R & D Management* 1974, 4(3), 127-34.

BRUNO A V & OTHERS : Reassessment of technological forecasting in a small company *Sloan Management Review* 1974, 15(3), 89-97.

BRUNO A V : Technological forecasting in small companies *Sloan Management Review* 1973, 15(1), 49-65.

BRUSILOVSKY B Y : Partial and system forecasts in scientometrics *Technological Forecasting & Social Change* 1978, 12(2-3), 193-200.

BUNDGAARD-NIELSEN M: Forecasting in the chemical industry *Industrial Marketing Management* 1972, 1(2), 205-10.

CATLING H : Forecasting the textile scene *R & D Management* 1971, 1(3), 141-46.

CETRON M J : Technological forecasting—a prescription for the military R & D manager *Naval War College Review* 1969. 21(8), 31.

———————— : Using technological forecasting in planning *European Business* 1968, 115-201.

CETRON M J, BARTOCHA B : BRAILLE—a forecasting model to aid research and development planning *Futures* 1969, 1(Dec), 479-87.

CETRON M J, DICK D N : Producing the first navy technological forecast *Technological Forecasting* 1969, 1, 185-95.

CETRON M J, WEISER A L : Technological change, technological forecasting and planning R & D—a view from the R & D manager's desk *George Washington Law Review* 1968, 36(5).

CETRON M J, MAHINSKE E B : Value of technological forecasting for the research and development managers *Future* 1969, 1(1), 21-33.

CURRILL D L : Technological forecasting in six major UK companies *Long Range Planning* 1972, 5(1), 72-77.

DAVIS N : Prospecting for steel—forecasting techniques and case studies *Futures* 1974, 6(5), 404-12.

DAY L H : An assessment of travel communications substitutability *Futures* 1973, 5(6), 559-572.

DOBROV G M : TA & TF for the management of R & D in the USSR. Paper presented at the Second International Congress on Technology Assessment, Ann Arbor, Michigan October 1976.

DOBROV G M & OTHERS: Forecasting welding technology *Technological Forecasting & Social Change* 1978, 12(2-3), 247-54.

DOBROV G M, MALAYA M P : Methods of forecasting parameters of equipment *Technological Forecasting & Social Change* 1978, 12(2-3), 229-45.

DUNN M J & OTHERS : Use of technological forecasting techniques in Canada—a research note *Journal of Business Administration* 1976, 7(2), 105-14.

DUVIVIER J F : Technological advances and program risks *Technological Forecasting & Social Change* 1971, 2, 277-87.

EMERY F M : Next thirty years—concepts method and anticipations *Human Relations* 1967, 20, 217.

ENZER S : Case study using forecasting as a decision making aid *Futures* 1970, 2(4), 314.

FALK C E : Dynamics and forecasts of R & D funding *Technological Forecasting & Social Change* 1974, 6, 171-89.

FONTELA E : Industrial applications of cross-impact analysis *Long Range Planning* 1976, 9(4), 29-33.

———————— : Technological forecasting and corporate strategy *IFCEP Journal of Modern India* 1972, 1(1), 31-5.

FOODY J J : Technology forecasting and risk assessment in V/STOL transport area *Technological Forecasting & Social Change* 1971, 3, 89-98.

FORD D A : Shang inquiry as an alternative DELPHI—some experimental findings *Technological Forecasting & Social Change* 1975, 7, 139-64.

FOSTER R N, ROBERT H R : Integrated technological forecasting and planning system *Futures* 1970, 2(3-4), 231-44.

FULMER R M : Forecasting the future of associations *Association Management* 1971, 23 (December), 49-52.

GECHELE G B : Evaluating industrial technological forecasting *Long Range Planning* 1976, 9(4), 76-81.

GODET M : Scenarios of air transport development to 1990 by SMIC 74—a new cross impact method *Technological Forecasting & Social Change* 1976, 9, 279-88.

GOODMAN J : Television in the 'Seventies *Long Range Planning* 1973, 6(4), 63-5.

GOODWILL D Z : Look at the future impact of computer communication on everyday life *Technological Forecasting & Social Change* 1972, 4, 227-33.

GORDON T J, STOVER J : Using perceptions and data about the future to improve the simulation of complex system *Technological Forecasting & Social Change* 1976, 9(1-2), 191-211.

GRABBE E M, PYKE D L : Evaluation of the forecasting of information processing technology and applications *Technological Forecasting & Social Change* 1972, 4, 143-50.

HARRIS L A : Advanced composites—an assessment of the future *Astronautics & Aeronautics* 1976, 14(4), 22-23.

HAYDEN S : How industry is using TF ? *Management Review* 1970, 59(5), 4.

HENDERSON H : Coming economic transition *Technological Forecasting & Social Change* 1976, 8, 337-51.

HERMANN W D : Social engineering in the third world/*Technological Forecasting & Social Change* 1975, 7, 229-32.

HERZOG H W Jr. : Environmental assessment of future production-related technological change 1970-2000 (An input-output approach) *Technological Forecasting & Social Change* 1973, 5, 75-90.

HOFFMAN G A : Future electric automobiles *Technological Forecasting* 1969, 1, 173-83.

HUPKES G : Future of the motocar—alternative scenarios *Futures* 1973, 5(5), 457-68.

JANTSCH E : Technological forecasting in corporate planning *Long Range planning* 1968, 1(1).

JECKOVICH S : Technological forecasting as a guide for managerial planning *Long Range Planning* 1971, 4(1), 29-34.

JOHNSON J L : DELPHI forecast of electronics industry *Industrial Marketing Management* 1976, 5(1), 45-54.

———————— : Ten year forecast in electronics industry *Management Review* 1976, 65(8), 52-56.

JUDD R C : Use of DELPHI methods in higher education *Technological Forecasting & Social Change* 1972, 4, 173-86.

JULIUS M & OTHERS : A very Early Warning System for the rapid identification and transfer of new technology *Journal of the American Society for Information Science* 1977, 28(3), 170-4.

KAHN H, WEINER A J : Next thirty three years—a framework for speculations *Daedules* 1967, 96(3), 705-33.

KANE J, VERTINSKY I B : Arithmetic and geometry of the future *Technological Forecasting & Social Change* 1975, 8, 115-30.

KAUFMANN F : Hard and soft health technology of the future/ *Technological Forecasting & Social Change*, 1973, 5, 67-74.

KOLBEL H, SCHULZE J : Influence of chemical innovations on future developments *Technological Forecasting & Social Change* 1970, 2, 195-220.

LAKHANI H : Diffusion of environment—saving technological change—a petroleum refining case study *Technological forecasting & Social Change* 1975, 7, 33-55.

LANFORD H W, IMUNDO L V : Approaches to technological forecasting as a planning tool *Long Range Planning* 1974, 7(4), 49-58.

LIPINSKY E S : Applications of relevance tree techniques in technological forecasting in paint technology *Journal of Paint Technology* 1960, 41, 17A-22A.

LOOKE H B : Forecasting in the field of chemicals *Industrial Marketing Management* 1972, 4, 417.

McDANIEL D E : Transportation forecasting a review *Technological Forecasting & Social Change* 1972, 3, 367-89.

McLEAN M, HOPKINS M : Problems of world food and agriculture—projections, models and possible approaches *Futures* 1974, 6(4), 309-18.

MARTINO J P : Examples of technological trend forecasting for research and development planning *Technological Forecasting & Social Change* 1970, 2(3-4), 247-60.

MARTINO J P : Technological forecasting and the autonomy of technology *Technological Forecasting* 1969, 1, 73-81.

———— : Technological forecasting in industry *Futurist* 1972, 6 4), 167.

———— : Technological forecasting for the chemical process industries *Chemical Engineering* 1971, December 27, 54-62.

MARTINO J P, CONVER S K : Stepwise growth of electric generators size *Technological Forecasting & Sccial Change* 1972, 3, 465-71.

MENON K A P, BOWONDER B : Model for forecasting wheat production *Technological Forecasting & Social Change* 1978, 11(3), 261-71.

MOHAN N C Jr : Application of trend concepts in forecasting type setting technology *Technological Forecasting & Social Change* 1972, 3 2), 225-53.

MOORE C G, POMREHN H P : Technological forecast of marine transportation system 1970 to 2000 *Technological Forecasting & Social Change* 1971, 3, 99-135.

NORTH H Q : Technological forecasting and its role in planning *Pazdziernick* 1967, 53.

NORTH H Q, PYKE D L : Technological forecasting to aid R & D planning *Research Management* 1969, 7, 289-96.

———— : Probes of the technological future *Harvard Business Review* 1969, May-June 68-82.

OSTWALD P F : Technology forecasting applied to numerical control *Industrial Engineering* 1971, 3(10), 52-5.

PARKER E F : British chemical industry in the 1980's—a DELPHI method profile *Chemistry and Industry* 1970, January.

ROHATGI K & OTHERS: Technological forecasting and research inputs in the area of birth control technology *Journal of Scientific & Industrial Research* 1974, 33(12), 625-34

———— : DELPHI & technology monitoring study of the future of aluminium industry in India *Journal of Scientific & Industrial Research* 1976, 35(11), 649-56.

ROHATGI K, BOWONDER B : Potential use of technological forecasting in planning materials research *Journal of Technology* 1972, 14, 151.

ROHATGI P K & OTHERS : Foundry industry of India towards 2000 *Journal of Scientific & Industrial Research 1978*, 37(1), 1-16.

ROHATGI P K, BOWONDER B : Technological forecasting in planning production activities *Economic Times* 29 January 1974, p. 5, col. 3-8; *Ibid* 30 January 1974, p. 5, col. 3-8.

ROHATGI P K, BOWONDER B : TF in the area of metals and alloys Paper presented at the IIM Annual meeting, Varanasi 1973.

ROHATGI P K, WEISS C : Technology forecasting for commodity projections—a case study on the effect of subsititution by aluminium on the future demand for copper *Technological Forecasting & Social Change* 1977, 11(1), 25-46.

ROMAN D D : Technological forecasting in the decision *Academy of Management Journal* 1970, 13(2), 127-38.

ROTHKOPF M H : Economic model of world energy 1900-2020 *Long Range Planning* 1973, 6(2), 43-51.

RUSHING K : Developing the driverless tractor *Agricultural Engineer* 1971, May, 260-2.

SAHAL D : Cross impact analysis and prediction of technological development—a case study of farm tractors *IEEE Transactions on Engineering Management* 1975, 22(2), 76-9.

———— : On the conception and measurement of trade-off in engineering systems—a case study of the aircraft design process *Technological Forecasting a Social Change* 1976, 8(4) 371-94.

SCHWARZ S : Aspects of visual communication and the future *Technological Forecasting & Social Change* 1973, 4, 409-21.

SHILLIFF K, SMITH R D : Forecasting method for setting short-range research objectives *Research Management* 1972, 15(2), 24-33.

SHRIEVER B A : Should technological forecasting be tailored to user needs ? *Armed Forces Management* 1967, November.

SIMMONDS W H C : Industrial behaviour patterns *Futures* 1975, 7(4), 284-92.

———————: Analysis of industrial behaviour and its use in forecasting *Technological Forecasting & Social Change* 1972, 3, 205-24.

SINGH M : Technological forecasting activities in selected U. S. federal agencies *Technological Forecasting & Social Change* 1978, 11(4), 297-301.

SMIL V : Energy and the environment—a DELPHI forecast *Long Range Planning* 1972, 5(4), 27-32.

SOMMERS A N, LEIMKUHLER H F: Nondemographic factor V/STOL prediction model *Technological Forecasting* 1969, 1, 163-72.

STYHR H J : Forecasting Danish nitrogen fertilizer consumption *Industrial Marketing Management* 1977, 6, 211-22.

SULLIVAN W G : Cross-impact analysis of the solar space heating and cooling industry *Industrial Management (USA)* 1978, 20(4), 17-21.

SURGUCHOV G D : Problem-oriented modeling in Industrial technology—the steel industry *Technological Forecasting & Social Change* 1978, 12(2-3), 255-72.

SWAGER W L : Strategic planning *Technological Forecasting & Social Change* 1972, 4, 85-99. *Ibid* 1972, 4, 151-72 *Ibid* 1973, 4, 283-300.

———————: Technological forecasting for practical planning *Petroleum Management* 1966, July, 61-6.

SWAGER W L: Technological forecasting in planning—a method of using relevance trees *Business Horizons* 1973, 16(1), 37-44.

———————: Technological forecasting in R & D *Chemical Engineering Progress* 1969, 65(12), 39-46.

THOMAS H : Debiasing of forecasts in research and development *R & D Management* 1971, 1(3), 119-23.

THURSTON P H : Make TF serve corporate planning *Harvard Business Review* 1971, 49(5), 98-102.

UTTERBACK J M, BURACK E H : Identification of technological threats and opportunities by firms *Technological forecasting & Social Change* 1975, 8(1), 7-21.

UTTERBACK J M, BROWN J W : Monitoring for technological opportunities *Business Horizons* 1972, 15(5), 5-15.

UTTERBACK J M : Process of technological innovation—a study of the origination and development of ideas for new scientific instruments *IEEE Transactions on Engineering Management* 1971, November, 124-31.

WATERS R C : Impact of technical progress on unit price of selected products in developing industries *Technological Forecasting & Social Change* 1972, 3, 473-9.

WELTY G : Critique of some long range forecasting developments *Bulletin of International Statistical Institute* 1971, 54, 403-8.

WIENER H B : Forecasting technology—luck and judgement in the chemical industry *Futures* 1977, 9(3), 182-93.

WILMOTTE R M : Engineering truth in competitive environment *Materials Management Journal of India* 1970, 11(9), 193-203.

WILSON D G : Future of the bicycle its problems and its potentialities *Long Range Planning* 1975, 8(2), 81-88.

YERSHOV V U, SALTYSOV I V : On determining the future impacts research and development solutions *Technological Forecasting & Social Change* 1978, 12(2-3), 165-74.

POLICY STUDIES

A BOOKS

ASCHER W : *Forecasting—an appraisal for policy-makers and planners Baltimore*, The Johns Hopkins University Press, 1978.

BRONWELL A B : *Science and technology in world of the future.* NY, John Wiley & Sons, 1970.

GOLDSMITH M Ed : *Pradicament of man—an examination of policies for the futures.* England, Infortink, 1972.

HAHN W A, GORDEN K F : *Assession the future and policy planning.* NY, Gordon & Breach Science Publishers, 1973.

INDIA, NATIONAL COMMITTEE ON SCIENCE & TECHNOLOGY : *Background papers—submitted to the futurology panel.* 1975.

———————: *Science and technology plan 1974-79.* New Delhi, 1973.

OWEN H, SCHULTZE C L *Eds : Setting national priorities—the next ten years.* Washington, the Brooking Institution, 1976.

B ARTICLES

BRUCK HAUS W L : Quantitative analytical methodology for judgemental and policy decisions *Technological Forecasting & Social Change* 1975, 7: 127-37.

BRONWELL A B : Technology forecasting in the formulation of national policy *Industrial Marketing Management* 1972, 1(4), 431-9.

CETRON M J : Method for integrating goals and technological forecasts into planning *Technological Forecasting & Social Change* 1970, 2, 23-51.

COENEN R : Use of technological forecasts in government planning *Research Policy* 1971-72, 1(2), 156-72.

DOBROV G M : Systems assessment of new technology for decision-making in government and industry—part II-case studies *Technological Forecasting & Social Change* 1978, 12(2-3), 95-109.

DOBROV G M, SMIRNOV L P: Forecasting as a means for scientific and technological policy control *Technological Forecasting & Social Change* 1972, 4(1), 5-18.

DROR Y: Technology forecasting and policy making reform *Technological Forecasting* 1969, 1(2), 109-111.

GOLOVANOV L V, SARKISYAN S A: Forecasting the development of large technical systems *Technological Forecasting & Social Change* 1978, 112(2-3), 175-84.

GLUSHKOV V M & OTHERS: CMBA experience in multinational forecasting of science and technology advance *Technoloical Forecasting & Social Change* 1978, 12(2-3), 111-23.

HAZELTON J E: Impact on raw material markets of environmental policies *Technological Forecasting & Social Change* 1972, 3, 353-66.

JANTSCH E: Organisation of technological forecasting in the Soviet Union *Technological Forecasting* 1969, 1, 83-6.

————: Technological forecasting at national level in Japan *Technological Forecasting* 1970, 1, 325-7.

————: Technological forecasting for a dynamic science policy *Chemical Age of India* 1968, 19, 4-99.

TWISS B: Economic perspectives of technological progress—new dimensions for forecasting technology *Futures* 1976, 8(1), 52-63.

LETTER FROM THE EDITOR-IN-CHIEF

Every enterprise has to contend against forces both external and internal and utilise the resources for effective enterprise operations consistent with enterprise objectives. In this it has to rely on the knowledge and experience of its operating members which often come in conflict with the desired expectations generated in the enterprises. As such there is a lack of compatibility between expectations and the potentialities of the system to meet these expectations.

The art of management consists of overcoming the dilemmas without sacrificing the organisational needs. Obviously it is not confined merely to the art of using the resources but also of optimising this use, and overcoming the stresses and strains which are a necessary part of a dynamic system. In fact stresses and strains are symptomatic of lack of planning and pragmatic policy execution. Effective management not only plans for the present or the expected but also for the future and the unexpected thereby causing the unexpected to become expected. In this process some of the dilemmas which a manager must overcome may be characterised as follows :

(i) **That given the opportunity and the resources a Manager can achieve the expected.**

In practice this does not happen because the resources are never enough. Even when there are plentiful resources in the absence of a proper "Strategy", results cannot be achieved. In fact, it is not resources which limit decisions—it is decisions which limit the resources.

(ii) **That activities in an enterprise develop momentum according to the pressures built.**

This leads to psychology of counter-acting pressures while allowing things to move. Any activity under pressure is indicative of a lack of foresight and a poor appreciation of the perspective of enterprise and its goals.

(iii) **That Managers are highly intelligent people.**

It is a strange paradox that high intelligence among Managers leads to complacency and at times even destroys the process of "collective thinking" and "team work". It also becomes a road block in solving problems which are an essential part of a Manager's task. It has also to be recognised that while dealing with a large body of people average intelligence is always the rule. To make people work as a team and to solve common problems, additionally requires a sense of identification and compatibility. Too much reliance on intelligence alone may not be very conducive to the success of a Manager.

(iv) **That problems are a continuing feature of any system.**

Problems are of a never ending nature. A Manager who is obsessed with the problems has to overcome these by finding time for planning and organising and for giving new directions to the enterprise activities. In solving problems there are always alternatives available and if a Manager makes his choice only from these alternatives, he cannot be creative. A Manager has therefore to search for new alternatives and in the event two alternatives are available he should be ready to look for the third one.

(v) **A Manager's personal visibility is always high.**

While it is undoubtedly true that a Manager enjoys better visibility as compared to those down the line, it should not blur his vision. There is always a danger of a Manager becoming a victim of the limelight and getting dazed. This is not merely a matter of risk and danger to the Manager but also to the enterprise as a whole. The visibility of a Manager should not lead to distortion of either values or of understanding.

(vi) **A Manager must take decisions.**

In taking decisions a Manager must avoid falling into the 'intelligence trap' and getting into the vicious circle of overcoming problems. His primary task is to solve problems by concentrating on alternatives which would redefine the problem. This is necessary for obtaining results, for lowering unit cost and exercising judgement in doing the right things at the right time.

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Profit Maximization and Decision Making Approach : A Managerial Case Study

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The paper deals with a managerial case study for a business firm where the units for a commodity are produced, stored and sold under the given market situation. The profit maximisation model is presented and is utilized to meet the targeted demand for future production.

The optimisation framework has been used very widely in decision making procedures. An important task of management is to choose an optimum course of action from among a given set of identified actions. Practitioners and research workers have given considerable attention to problems involving maximisation of profit as well as minimisation of cost.

The total cost along with total revenue determines the profit level of a business concern. Management tries to generate optimum levels of output, use the least cost combination factors of production, increase factor productivities and improve organisational efficiency. Hence, cost and production analysis plays a significant role in managerial decision making. Production analysis frequently proceeds in physical terms while the cost analysis proceeds in monetory terms [9]. Moreover, inventory costs related to production planning, scheduling and inventory control may include the costs of handling the product in and out of inventory. The costs shall represent only those out of pocket expenditures or foregone opportunities for profit whose magnitude is affected by the schedule or plan [7]. However, production and inventory control decisions are typically relatively insensitive to small variations in cost factors (indeed many cost elements can not be determined accurately), hence it is worthwhile and interesting to consider production and inventory costs together to maxlmise the profit for the system as a whole.

In this paper the linear programming approach [2] for profit maximisation for a firm is

studied. The profit is determined by the total revenue together with the total cost which includes the production cost as well as the total inventory cost. From the analysis of the past data, under deterministic and known demand, using the resources that are available, the optimum values of the corresponding labour, capital and production are determined to achieve the maximum profit for the firm.

2. Basic variables

Let us define :

Q = The units of production of the commodity X at time t (t=1, 2,.....N).

K = Invested capital in the production of the commodity X at time t (t=1, 2, ...N).

L = Labour employed in the production of the commodity X at time t (t=1, 2,.....N)

C = Cost per unit of production at time t (t=1, 2,.....N).

p = Price per unit of commodity produced at time t (t=1, 2,.....N).

R = Demand rate for the period t (t=1, 2, ... N).

Q = Number of units in inventory (lot size) at time t (t=1, 2,.....N).

3. Assumptions :

The mathematical model is derived under the following assumptions :

(1) The firm produces a single commodity for which the demand is deterministic and known.

(2) The production function for the single commodity X produced by the firm is assumed to be linear.

(3) Warehouse attached to the production unit follows lot size inventory model.

(4) Shortages are not allowed to occur.

(5) The lot size q is functionally specified with the total production by the relation :
$q=f(Q), (q>o, Q>o)$.....(1).
which is a function of capital and labour. Hence, the lot size is a function of capital and labour. Thus in general we may have,
$q=\phi(K, L), (K>o, L>o)$.....(2).

(6) Unit cost of production C, inventory holding cost C_1 and replacement cost C_3 are known constants.

(7) Selling price per unit of the commodity produced remains almost steady under the given market situations.

(8) The enterpreneur has to take care of the limited amounts of labour and capital resources that are available.

4. Mathematical Model

Let us consider the production function as :

$Q=\alpha K+\beta L, (\alpha>o, \beta>o)$.....(3).
where, α and β are respectively the marginal physical product of capital and marginal physical product of labour. The elasticity of substitution of factors of production for this production function is infinite.

The productive firm produces the single commodity in question. The produced commodity is stored in the form of inventory by the firm and it is also sold by the firm according to the market demand.

With the average cost of production equal to C per unit, the total cost of production is given by $C(\alpha K+\beta L)$.

The total inventory cost for this lot size system is given by [8] $\frac{C_1 q}{2}+\frac{C_3 R}{q}$

Hence, the total cost of production and storage of the commodity produced and stored by the firm is given by :

$$C^*=c(\alpha K+\beta L)+\frac{C_1 q}{2}+\frac{C_3 R}{q} \quad \text{.....(4).}$$

According to Hanssman [3], if the produced units are stored and sold by the firm itself at the unit selling price of p, the total profit (net revenue) of this firm is given by :

$$\pi=Rp-\left[C\alpha K+\beta L)+\frac{C_1 q}{2}+\frac{C_3 R}{q}\right] \quad \text{.....(5).}$$

By assumption (5), since $q=\phi(K,L)$, the functional relationship for q may be considered as,

$$q=\delta.e^{mk+nl}, (m>o, n>o, \delta>o) \ldots\ldots\ldots\ldots (6).$$

This suggests that a change in capital and labour employed brings in a corresponding change in output and the lot size q will be affected accordingly.

Hence from (5),

$$\pi=R \cdot p-\left[C(\alpha K+\beta L)+\frac{C_1\delta e^{mk+nl}}{2}+\frac{C_3R \cdot e^{-(mk+nl)}}{\delta}\right] \ldots\ldots\ldots (7).$$

A simplified approach for the above profit function (7) can be considered by approximating the above function under the assumption $mk+nl \leqslant 1$, so that a linear approximation will simplify (7) as :

$$\pi_1=E-D\alpha \cdot K-D\beta L \ldots\ldots\ldots\ldots\ldots\ldots (8).$$

where,

$$\left.\begin{aligned} E &= R \cdot p-\frac{C_1\delta C}{2}-\frac{C_3R}{\delta} \\ D\alpha &= C\alpha+Dm \\ D\beta &= C\beta+Dn \\ D &= \frac{C_1\delta}{2}-\frac{C_3R}{\delta} \end{aligned}\right\} \ldots\ldots\ldots\ldots (9).$$

A decision making approach leads to determine the optimum amounts of labour and capital inputs so that the profit

π_1 for the firm is maximum.

If all the variables are measured in value terms, (8) can be maximised using the linear programming method [2].

To solve this problem to determine the optimum use of input factors of production, a linear programming problem may be formulated first by considering the constraints as under :

(a) Capacity constraint of the firm

(b) Production constraint

(c) Labour utilisation constraint

(a) Capacity constraint

Here we may put a constraint representing the limited resources that are available. Thus the constraint for labour and capital that can be utilised is given by :

$$K+L \leqslant IC \ldots\ldots\ldots\ldots\ldots\ldots (10).$$

where, IC = Total investment capacity of the firm.

(b) Production constraint

The total amount produced should meet at least with the known targeted demand rate R^*.

Thus $Q \geqslant R^*$ which leads to,

$$\alpha^*K+B^*L \geqslant R^* \ldots\ldots\ldots\ldots\ldots\ldots (11).$$

(c) Labour utilisation constraint

The amount of labour employed should be atleast equal to a given minimum number of employees equal to $\int$. This leads to the constraint (in value terms) as :

$$L \geqslant \int \ldots\ldots\ldots\ldots\ldots\ldots (12).$$

Hence the linear programming formulation for this profit maximisation problem is given by :

$$\left.\begin{aligned} &\text{Maximise : } \pi_1=E-D\alpha K-D\beta L \\ &\text{Subject to, } K+L \leqslant IC \\ &\qquad \alpha^*K+\beta^*L \geqslant R^* \\ &\qquad L \geqslant \int \\ &\qquad K \geqslant O, L \geqslant O \end{aligned}\right\} \ldots\ldots\ldots (13).$$

5. Application

"ABC Manufacturing Co., Ltd.," produces a certain commodity X. From the past data the production function of the product is found to be linear and it is estimated by the relation :

$$Q=(54.6)K+(3.1)L \ldots\ldots\ldots\ldots\ldots (14).$$

Similarly, the lot size q follows the law which is estimated as :

$$q=(122.056).\exp\{(0.00567)K+(0.000421)L\} \ldots\ldots\ldots (15).$$

Table 1

Ingredients of production and cost for the profit maximisation Model : Case Study of ABC Co.

Year	No. of Machinery (K)	No. of Employees (L)	Production (in Units) (Q)	Price Per Unit (P) ('000 Rs.)	Labour Employed ('000 Rs.)	Value of production ('000 Rs.)	Capital Invested ('000 Rs.)	Lot Size	Demand Rate (R)	Cost of Production per unit of commodity ('000 Rs.)	Total Cost of Production ('000 Rs.)	Total Inventory Cost ('000 Rs.)	Net Profit ('000 Rs.)
1970	29	584	3394	0.1855	185.712	629.5870	186.2844	184	3210	0.1451	492.4694	9.6488	93.3368
1971	30	590	3467	0.1856	189.980	643.4752	193.4430	186	3283	0.1452	503.4084	9.7578	96.1586
1972	32	598	3601	0.1857	197.340	668.7057	207.440	188	3415	0.1452	522.8652	9.9510	101.3493
1973	34	609	3744	0.1858	206.451	695.6352	221.0374	191	3556	0.1453	544.0032	10.1542	106.5474
1974	36	623	3896	0.1858	217.427	723 8768	235.0476	196	3705	0.1453	556.0888	10.3650	111.9352
1975	39	641	4116	0.1860	230.760	765.5760	255.3759	199	3920	0.1454	598.4664	10.6612	119.9924
1976	42	663	4348	0.1860	245.973	808.7280	275.6922	205	4149	0.1456	633.0688	10.9682	127.6770
1977	45	690	4596	0.1861	262.890	855.3156	296.1855	211	4391	0.1458	670.0968	11.2835	135.7848
1978	49	722	4914	0.1861	283.024	914.4954	323.5568	218	4703	0.1459	716.9526	11.6776	146.5981
1979	53	760	5249	0.1862	305.520	977.3638	351.0770	227	5031	0.1461	766.8789	12.0778	157.8155

The production data and other numerical details for the company are given in Table 1.

The company wants to expand its business and the target for future production is to be planned so as to fulfill the demand for this commodity research to $R^* = 5690$ units.

The optimum production using the optimum capital that can be invested by the number of machines and optimum number of machines and optimum number of employees that can be employed are determined by the linear programming method.

Table 2 represents the different values of the constraints for the next targeted production planning.

Table 2

Constraints for targeted production planning

Symbol	Description	Numerical Value
C_1	Inventory holding cost per unit of commodity per year.	0.0533 ('000 Rs.)
C_3	Replenishment cost per lot per year.	0.272 ('000 Rs)
C	Expected cost per unit of commodity for planning period.	0.1462 ('000 Rs.)
p	Expected price per unit of commodity for planning period.	0.1864 ('000 Rs.)
W	Expected wage rate for planning period	0.479 ('000 Rs.)
C_k	Expected cost per machine for planning period.	6.7027 ('000 Rs.)
IC	Capacity constraint of the firm in terms of the production investment.	900 ('000 Rs.)
R^*	Expected demand rate in value terms	1060.616 ('000 Rs.)
$\int$	Expected minimum labour requirement in value terms to fulfill the desired objectives.	376.74 ('000 Rs.)
α^*	The lower bound of the marginal products of capital for the production target.	1.4732

$$\left\{ \alpha^* = \frac{1}{n-1} \sum_{t=1}^{n-1} \frac{\triangle Kt/Kt}{\triangle Qt/Qt} \right\}$$

β^*	The lower bound of the marginal products of labour for the production target.	1.1249

$$\left\{ \beta^* = \frac{1}{n-1} \sum_{t=1}^{n-1} \frac{\triangle Lt/Lt}{\triangle Qt/Qt} \right\}$$

The management of the firm wants to maximise the profit. The problem is to determine the optimum values of capital, labour and production so as to realise the maximum profit.

From the past data and for the targeted planning, the linear programming problem can be stated as :

$$\left.\begin{array}{l} \text{Maximise :} \\ \pi 1 = 1044.6831 - (7.929067)K - (0.449251)L \\ \text{Subject to,} \\ K + L \geqslant 900 \\ (1.4732)K + (1.1249)L \geqslant 1060.61 \\ L \geqslant 376.742 \\ K \geqslant 0,\ L \geqslant 0 \end{array}\right\} (16)$$

Using graphical method, the profit is maximised at the point A, whose co-ordinates are (417.0969, 396.612) as shown in the diagram. The number of machines and the number of employees are determined using the expected wage rate and the expected cost per machine during the planning period. The numerical data for various ingredients of price and cost are given in Table 2.

The optimum values of the decision variables using this method are given as follows :

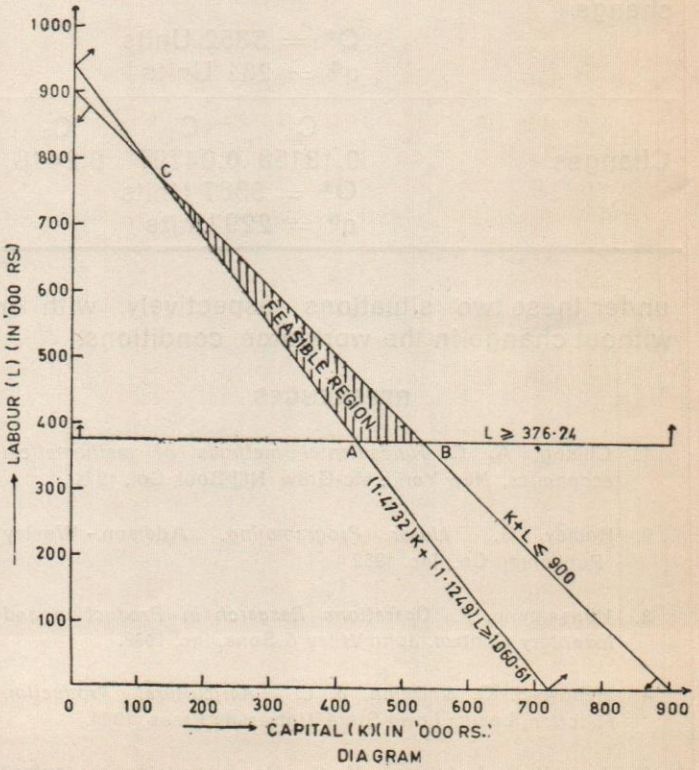
Optimum number of machines	= 62
Optimum number of employees	= 828 persons
Optimum production	= 5962 Units
Optimum lot size	= 246 Units
Optimum profit	= 181.5656 ('000 Rs.)

6. Sensitivity

It may be interesting to observe the effect of changes in the values of the cost and price parameters in the model on the overall profit for the system. This is achieved by the sensitivity analysis [6], where all the parameters decrease or increase simultaneously by a fixed amount of 10%. This takes care of the inflationary and deflationary situations for the price of the commodity. These situations are represented in Table 3 and Table 4 respectivly.

7. Concluding Remarks :

From the above sensitivity analysis, it can be concluded that while the labour conditions do not change, the optimum profit of the firm increases by 20.95% under inflationary situations; whereas the optimum profit increases by 22.38% when the labour requirement changes. Under the deflationary situation, when the labour requirements do not change, the optimum profit decreases by 20.75% and when the labour requirement observes a corresponding change, the optimum profit under this situation decreases by 21.77%. There is not much significant change in the optimum output as well as the optimum lot size



DIAGRAM

Fig. 1 Profit Maximisation

Table 3

Sensitivity : Optimum Solution in Inflationary Situation

Condition Imposed upon work force	Increase in the values by 10% uniformly								
	C	C_1	C_3	C_k	w	P	Ic	R*	∫
Does not change	0.16082	0.05863	0.2992	7.3729	0.5269	0.20504	990.0	6259	828
	Q* = 6553 (Units) q* = 262 (Units) Z* = 219.6059 ('000 Rs.) (20.95% increase)								
Changes	C	C_1	C_3	C_k	W	P	Ic	R*	∫
	0.16082	0.05863	0.2992	0.16082	0.5269	0.20504	990.0	6259	911
	Q* = 6537 (Units)			q* = 263 (Units)			z* = 222.2084 ('000 Rs.) (22.38% increase)		

Table 4

Sensitivity : Optimum Solution in Deflationary Situation

Condition Imposed upon work force	Decrease in the values by 10% uniformly								
	C	C_1	C_3	C_k	W	P	Ic	R*	∫
Does not change	0.13158	0.04797	0.2448	6.03243	0.4311	0.16776	810	5121	828
	Q* = 5352 Units q* = 231 Units			Z* = 143.8868 (20.75% decrease) ('000 Rs.)					
Changes	C	C_1	C_3	C_k	W	P	Ic	R*	∫
	0.13158	0.04797	0.2448	6.03243	0.4311	0.16776	810	5121	745
	Q* = 5367 Units q* = 229 Units			Z* = 142.0292 ('000 Rs.) (21.77% decrease)					

under these two situations respectively, with or without change in the workforce conditions.

REFERENCES

1. Chiang, A. C. *Fundamental methods of mathematical economics.* New York : Mc-Graw Hill Book Co., 1974.
2. Hadley, G. *Linear Programming.* Addison - Wesley Publishing Co., Inc. 1962
3. Hanssmann, F. *Operations Research in Production and Inventory Control.* John Wiley & Sons, Inc. 1962.
4. Heady, E. O. & Dillon, J. L. *Agricultural Production Function*, Lowa : Lowa State University Press, 1964.
5. Jani, B. B. & Jaiswal, M. C, On maximising the output of an Industry—A mathematical programming approach. *Vishleshan,* March Vol-3, No. 4, 1977.
6. Jani, B. B. & Jaiswal, M. C. Order- level lot-size Inventory model under the influence of the market policy *Gujarat Statistical Review,* April, Vol.-VII No. 1, 1980
7. Magee, J. F. *Production Planning & Inventory Control.* New York : Mc-Graw Hill Book Co , 1958.
8. Naddor, E. *Inventory System.* John Wiley & Sons, Inc. 1966.
9. Nemmers, Erwin, Esser. *Managerial Economics. Text & Cases.* John Wiley & Sons, Inc. 1967.
10. Parikh A and Ajay Kumar. Application of Linear Programming and Gravity Models to Transportation planning *Vishleshan*, March, Vol.-VI, No. 1980.
11. Wagner, H M. *Principles of O. R, with application to managerial decision.* Prentice-Hall Inc. 1974.

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Realities of Participation : The Case of an Engineering Industry

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Although the different participative schemes introduced by the Government have not met with the desired success, the results of this study indicate that participative management, if properly designed and implemented, can achieve very important objectives and thereby increase organisational effectiveness and efficiency.

Participation is an overeaching concept which includes a variety of forms and practices. Included among those are practices associated with industrial democracy, with the enlargement and enrichment of operational tasks and with management styles which seek to improve effectiveness through the involvement of workers at all levels in the decision-making process (Hedben and Shaw, 1977). In USA, (and to some extent elsewhere), participation is currently thought of primarily in terms of informal interaction. Outside USA, participation tends to mean workers' participation in management, usually in the form of formal mechanisms which permit representatives of workers to influence or even control organisation decisions. Almost everywhere the supporters of participation claim that it is not only morally sound, but it reduces alienation and improves morale (Straus and Rosenstein, 1970). Further it enhances productive efficiency, fosters industrial harmony, and enriches the human personality (Derber, 1970).

Workers' participation has become a major political, social and economic issue in many countries. Yugoslavia, West Germany, United Kingdom, United States, Sweden, France, Belgium, Denmark, etc. have been among those experimenting with this theme, though it has assumed different forms in different countries in order to meet their special needs. The Indian version of workers' participation can be dated as far back as 1920 when the workers and employers in Ahmedabad Textile Industry agreed to settle disputes by mutual discussion. The concept of workers' participation in management has also

become a part of government labour policy since Independence onward. Several attempts have been made to experiment with various forms of participation like Works Committees (1947), Joint Management Councils (1958), workers in the Board of Directors in Port Trusts and Nationalised Banks (by legislation in 1963 and 1970 respectively), Shop and Plant Councils (1975 Scheme), but there has been very little success in promoting effective working of participative forums. However, one thing very clear from the current literature is that all countries which tried one or the other form of workers' participation in management are still keen to continue with their scheme and improve upon them and also in most of the countries, a certain amount of governmental support through legislation or other forms is being extended in promoting participative management.

Some Research Studies

Ever since the findings of the Mayo experiments, participative management has remained a favourite theme with the social scientist. Numerous field studies, experiments, case studies and surveys have been conducted in the organizational setting to understand the dynamics of participation.

In his conceptual framework for participation, Kenneth Walker (1974) has discussed the role of situational and human factors in determining the extent of actual participation. Walker acknowledged the significance of employees' participatory desire by maintaining that though situational factors determine the participation potential of a particular enterprise, the human factors (like participatory desire) determine the extent to which this potential can be realised.

According to Moulder (1971) motivation is the most important determinant of participation. Moulder has argued that in most countries (he cites studies conducted in Netherlands, Yugoslavia, etc.), employees have a low desire to participate in managerial decision-making. Thus there is a need to study objectively the extent of employees' willingness to participate in organisational decision-making and the areas in which they want to participate.

Several studies of workers' participation in management in India reveal that there is a great deal of misconception and confusion amongst the parties with regard to the usefulness of the scheme itself. In addition, there is hardly any clarity regarding the method of creating an environment of participativeness (Thakur and Sethi, 1972). Studies conducted by Das (1964), Van Dusen Kennedy (1966), Subramaniam (1967), Pandit (1962), Mhetras (1966), Alexander (1972) have also revealed that the various government schemes did not meet the desired success. Sheth (1972) conducted a study in six industries and came out with the conclusion that JMC would develop into an effective and viable participative forum if it could meet the perceived needs of the management and the employees at the lowest level of organization. In India very little attempt has been made to investigate participatory desire empirically at the micro level.

The Case of an Engineering Industry

Aims : The present case study in an engineering industry is designed to :

(i) determine the existing organizational climate for participative management,

(ii) identify the main objective of participative management as perceived by management personnel and workers,

(iii) assess the perceived and desired level of workers' influence in different decisions taken in the organization at various levels as expressed by management personnel and workers and also to identify the desired way of involvement of workers in different decisions,

(iv) identify the desired forms of participative management as expressed by management personnel and workers,

(v) evaluate the functioning of different participative forums in the organization.

About the Organization: The industry is situated in Bangalore and is a leading electrical equipment manufacturer. It started functioning in 1961 under the direct control of the industries department of the State Government and later it was converted into a State Government owned public sector undertaking. The industry

employs 5400 personnel of which 720 are supervisory and management staff. Majority of the employees (85%) are from urban area. Workers are adequately skilled and at least 60% of them have studied upto Matriculation. The technical staff (management) are also well equipped with professional knowledge. The industrial relations climate is quite cordial. The workers are strongly unionised, approximately 90% of the employees are union members, divided between three different unions affiliated to AITUC, BMS and INTUC. The wage rate of the workers is at par with other leading industries of the State. The statistics of sales turnover and profit margin reveals that the industry's performance is quite satisfactory.

Methodology

The information about the organisation, its product, nature of work force, trade unionism and industrial relations climate, the details of various participative forums working etc. were collected from various records and documents furnished by the industry and also through discussion with various authorities.

Appropriate questionnaires were developed to measure the views of various groups of management personnel and workers regarding the organization climate for participative management, objective of participative management, workers influence on various decisions (perceived and desired) and the desired way of taking these decisions, preference for different forms of participative management and effectiveness of functioning of present participative forums, etc. Thirty management personnel and 30 workers were personally interviewed on these scheduled questionnaries. Care was taken to include in the sample managers of all functions at different levels and also a few office bearers of different joint committees/participative bodies. Similarly the workers sample contained trade union office bearers, a few office bearers of different joint committees and employees of different categories. The confidentiality of individual responses was guaranteed.

RESULTS AND DISCUSSION

I. Organisation Climate for Participation

The workers' views were obtained on five items as given in Table I (a) and Management personnels views are taken on ten items as given in Table I (b).

The results in Table I (a) and I (b) indicate that the existing organisation climate is quite conducive for participative style of management.

Table I (a)

Perceived Views of the Workers (N=30)

Items		
1. Liking their own job	—	80% very much
2. Relationship with supervisors/managers	—	55% cordial and 33% fairly cordial
3. Relationship with co-workers	—	65% cordial, 30% fairly cordial
4. Free to approach supervisors/managers	—	70% fully and 20% to some extent
5. Opinion about top management	—	70% supportive to some extent

Table I (b)

Perceived Views of Management Personnel (N=30)

Items	Mean Score*
a. Subordinates are given a share in decision-making	2.9
b. Subordinates are informed of the true situations good or bad under all circumstances	3.2
c. Management remains aware of the state of the organization's morale and does every thing possible to make it high	3.0
d. Supervisors/managers are easily approachable	3.9
e. Managers/supervisors counsel, train and develop subordinates	3.2
f. Managers/supervisors communicate effectively with subordinates	8.5
g. Managers/supervisors show thoughtfulness for others	3.2
h. Managers/supervisors make changes in way of doing things	2.8
i. Managers/supervisors support subordinates when they make mistake not due to negligence or without any bad intentions	3.3
j. Managers/supervisors express appreciation when subordinates do a good job.	3.4
Average mean	3.24 st. dev.=0.3

* The Scale : Never = 1, Seldom = 2, To some extent = 3, Usually = 4, Always = 5.

II. Objective of Participative Management

Table II shows the first five objectives of participative management as perceived by management personnel and workers. Twelve alternative objectives were given out of which the respondents were asked to identify only five objectives rankwise. Amongst the first five ranks, identified by both groups, there are four common objectives. Management personnel feel increasing employee commitment to organisation is one of the first five objectives whereas workers feel deriving better amenities and service conditions by having influence in the decision-

Table : II

Objective of Participate Management : First Five Rankwise as Perceived by Management Personnel and Workers.

Rank** (Overall)	Management Personnel (N=30) Objectives	Score*	% of max. score	% opted for	Workers (N=30) Objectives	Score	% of max. score	% opted for
1	Increase productivity, job satisfaction, decrease absenteeism and reduce waste	123	82	90	Increase productivity improve job satisfaction, decrease absenteeism & reduce waste	128	85.3	93
2	Improve team work	63	42	80	Help employees to know about the running of an industry and thereby provide a democratic setup.	64	42.6	80
3	Increase employee commitment to organization	45	30	50	Improve team work	60	40.0	80
4	Help employees to know about running of an industry & thereby provide a democratic setup	33	22	60	Provide more peaceful, manager-subordinate & union management relations	60	40	60
5	Provide peaceful manager-subordinate & union-management relation	33	22	30	To derive better amenity & service condition for workers by having Influence in the decision-making process	46	30.6	53

* Max. score possible is 150, scoring is done as follows : 1st = 5, 2nd = 4, 3rd = 3, 4th = 2, 5th = 1.

** For overall rank 1st consideration is score, if scores are same then percentage opted for is considered as the criteria.

making process is one of the main objectives. Both the groups have identified, "Increase productivity, job satisfaction etc." as the number one objective and strikingly the score of workers and percentage opting for it are even higher than that of management personnel. Although the different participative schemes introduced by Government from Independence onward have not met with desired success, this result indicates that participative management, if properly designed and implemented in an organisation can achieve very important objectives and thereby increase organisational effectiveness and efficiency.

III. Workers' Influence in Decision-making

In total 21 decisions were identified, which are usually taken in an organization, and depending upon the level of management where the decisions are taken, these issues are put under five categories, i.e, distant level participation issues (6 issues), medium level participation (7 issues), local level participation (5 issues), issues which require cooperation from both management and worker at all level (2 issues), and bonus issue (one item). A distinction is made between perceived and desired level of influence on different decisions. As shown in Table III (a)* both the groups perceive that workers have very little influence over all categories of issues. However, both the groups have indicated that level of workers' influence

*The average mean scores for all items in each category of issues have been presented in the Table III(a), as the summary of the findings due to paucity of space. However, decisionwise analyses have been made for actual research purpose.

Table III (a)

Mean responses to workers influence in decision-making

Issues	Workers (N=30)			Management personnel (N=30)			Differences	
	Perceived	Desired	Diff. between desired & perceived	Perceived	Desired	Diff. between desired & perceived	Perceived workers vs perceived mgt. personnel	Desired workers vs desired mgt. personnel
a) Distant level participation (Issue of Mgt. prerogatives where workers interests are not immediately involved)	1.94	3.23	1.29	1.66	2.12	0.46	0.28***	1.11***
b) Medium level participation (Issues of Mgt prerogatives where workers interests are immediately affected)	2.23	3 81	1.58	2.80	3.15	0.35	-0.57+***	0.66***
c) Local level participation (Issues regarding workers' welfare programme and one's work)	2.20	4.00	1.80	2.74	3.52	0.78	-0.54***	0.48***
d) Issues which requires co-operation of workers and Mgt. at all levels	2.39	3.89	1.50	2.70	3.85	1.15	-0.31***	0.04*
e) Way of determining rate of bonus	2.66	3 93	1.27	2.60	3.20	0.60	0.06*	0.73**
f) All issues take together(As calculated from average of a to e)	2.28	3.77	1.49	2.50	3.16	0.66	0.22**	0.61***

Scale : No. influence=1, Very little inf.=2, Inf. to some extent=3, Quite a lot infl.=4, Inf. to great extent=5.

+ When Mgt. personnel score is more than workers score - sign is used & viceversa.

* Not significant, ** $p<0.05$, (two tailed t-test), *** $p<0.01$ (two tailed t - test)

should be more. Workers have shown maximum and minimum desire to participate in local level issues and distant level issues respectively whereas management personnel have expressed maximum and minimum interest to accept workers influence in issues which require co-operation from both sides at all levels and distant level issues respectively. The degree of congruence, between the desired level of workers influence as expressed by both groups in issues which require cooperation from both sides at all levels, local level issues, and medium level issues augurs well for the possibility of genuine participation in those issues.

Further the workers and management personnel's views regarding the desired way of involving workers in taking these decisions were obtained. They were asked to opt for one of the alternatives (i.e. information sharing, consultation, joint decision-making, collective bargaining/ negotiation, workers say to be accepted) for each of the 21 decision issues. Table III (b) shows the summary of the findings for each category of issues.

Except distant level issues and bonus issue both the groups have shown considerable desire for joint decision-making and consultation. This indicates that greater involvement of workers in medium level participation issues, local level issues and issues which require cooperation at all levels is possible. Further the participation has to go much beyond information sharing. However, in distant level issues majority of the management personnel feel that it is management's prerogative whereas workers' view is equally divided between three alternatives, i.e., joint decision-making, management prerogative and information sharing. Participation cannot be restricted to local level or medium level issues only if its success is desired in due course. Once participation has its proper footing in medium level and local lveel issues, it is expected that both groups will develop a climate for consultation or joint-decision-making in distant level issues also. To start with management should take proper care to have proper information sharing on distant level issues also.

Table III (b)

Desired way of participation for taking different categories of issues (only first three ranks in terms of percentage of respondent has been tabulated)

	Categories of Issues	Management personnel (N=30)			Workers (N=30)		
		Rank	Way/Type	% preferred	Rank	Way/Type	% preferred
a)	Distant level participation issues	I	Mgt. prerogative	50	I	Jt. decision-making	26.6
		II	Consultation	27	II	Mgt. prerogative	24.4
		III	Information sharing	16.5	III	Information sharing	22.2
b)	Medium level participation issues	I	Jt. decision-making	31.4	I	Jt. decision-making	38.0
		II	Consultation	23.0	II	Collection bargaining	23.8
		III	Collective bargaining	21.4	III	Consultation	20.9
c)	Local level participation issues	I	Jt. decision-making	58	I	Jt. decision-making	46.6
		II	Information sharing	16	II	Consultation & collective bargaining	17.3 (each)
		III	Consultation	14	III	Mgt. prerogative	9.3
d)	Issues which require Mgt. & Workers cooperation at all levels	I	Jt. decision-making	50	I	Jt. decison-making	36.6
		II	Consultation	15	II	Consultative	26.6
		III	Information sharing	15	III	Mgt. prerogative	16.6
e)	Bonus Issue	I	Jt. decision-making	30	I	Collective bargaining	73.6
		II	Consultation & Information sharing	20 (each)	II	Jt. decision-making	13.6
		III	Mgt. prerogative	20	III	Consultation	6.6

IV Form of Participative Management

Table IV shows the differernt forms of participative management preferred by management personnel and workers. Both the groups have identified workers representatives in joint committees at different levels as the first preference and workers acquiring share and representing in the Board of Directors as the second preference. This second preference is a major deviation from the central trade union leaders' views conveyed to government in this regard. Workers have given much importance to informal participative methods also. Strikingly, both the groups prefer to have workers representatives rather than union officials/representatives in various joint committees. The idea of having one to two workers nominated to the Board has received very poor response. However, workers have shown some interest to have parity in the Board whereas management personnel prefer it as the last alternative oniy.

V. Functioning of Different Participative Forums

Apart from unions involvement with management through negotiations and discussions there are some other joint committees, namely, works committee, shop councils (9 in number), joint council (plant level), canteen committee. Except the canteen committee, the functioning of other committees are far from satisfactory. The analysis of minutes of meetings these committees showed that during first year of inception of shop and joint councils (year 1976-77) there was initial enthusiasm amongst both groups. However, after one year of functioning both the groups have lost their interest in these forums. The main reasons for this unsatisfactory functioning are identified as (a) non-implementation of the unanimous recommendations, (b) these committees act as forums for information sharing only, (c) the scope of discussion is limited to production, safety and welfare matters only

Table IV

Form of participative management preferred by management personnel and workers

	Alternative forms	Mgt. Personnel (N=30)			Workers (N=30)		
		Score	% of max. Score	Rank	Score*	% of max. Score	Rank
a)	Having one or two workers nominated to the Board of Directors	99	47.1	6	86	40.9	6
b)	Having parity in the Board	72	34.2	7	108	51.4	4
c)	Workers acquiring share & representing in the Board	117	55.7	2	114	54.2	2
d)	Having workers representatives in various joint committees at different levels	165	78.5	1	122	51.0	1
e)	Through Union officials/representative only representing in various joint committees	111	52.8	3†	92	43.8	5
f)	Through suggestion schemes	111	52.8	4	40	19.0	7
g)	Through informal face to face sharing of decision-making at work place, job enrichment and enlargement, participative style of management etc.	105	50	5	108	51.4	3

* Maximum score possible is 210.

† Since 1st & 2nd preferences are more it is ranked 3.

Table V

Effectiveness of functioning of joint committees

Items	Workers (N=30)			Management personnel (N=30)			Differences	
	Perceived	Desired	Difference between desired & perceived	Perceived	Desired	Difference between desired & perceived	Perceived workers vs mgt. personnel	Desired workers vs mgt. personnel
a) Increasing production	2.54	4.3	1.76	2.1	4.14	2.04	0.44*	0.16+
b) Improving quality of product	2.63	4.7	2.07	2.0	3.85	1.85	0.63*	0.85**
c) Reducing cost of production	2.18	4.5	2.32	2.0	4.14	2.14	0.18+	0.36*
d) Eliminating waste	2.09	4.4	2.31	2.1	4.28	2.18	-0.01@+	0.12+
e) Reducing accidents	2.18	4.5	2.32	2.4	4.00	1.60	-0.22+	0.50**
f) Improve communication	2.00	4.5	2.50	2.4	3.85	1.45	-0.408	0.65**
g) Reducing work stoppages	2.27	4.1	1.83	2.14	3.85	1.71	0.13+	0.25+
h) Improving labour-mgt. relation	2.18	4.6	2.42	2.28	4.14	1.86	-0.10+	0.46*
i) Satisfying worker's urge for self-expression	1.90	4.0	2.10	2.28	3.85	1.57	-0.38+	0.400**
All items taken together (average mean)	2.21	4.4	2.19	2.18	4.00	1.82	0.03+	0.40**

Scale : Not at all=1, very little=2, To some extent=3, Quite a lot=4, To a great extent=5.
+ Not significant, ** $p<0.01$ (two tailed t-test), * $p<0.05$, @ when management personnel score is more than workers score—sign is used and vice versa.

whereas workers are interested in a much broader gamut of matters, i.e., starting from finance, marketing, personnel policy etc., (d) passive role by union, (e) management representatives in the committees are not clear whether they have the authority to take a joint decision, (f) workers' representatives want some authority at least in grievance handling, (g) duplication of some functions by works committee and shop and plant councils. The perceived level of effectiveness of these committees as expressed by both management personnel and workers also confirms the unsatisfactory functioning of these committees. However, both the groups feel that with proper care the effectiveness of the joint committees can be improved to a great extent. Further the respondents have identified the factors like quality of communication, lack of reward system, fear of giving up power by the managers and some of the managers style of functioning, lack, of proper educational background and knowledge about the organization on the part of the workers, political situation of the country and multiplicity of trade unions as the major constraints to participative management.

Summary and Conclusions

For the organization studied the findings can be summarised as below :

a) Both workers and management personnel perceived the common objectives of participative management and the existing organizational climate is also quite conducive for participative management. This implies that if properly designed and sincerely tried participative management can meet with the desired success in this organisation.

b) There is a considerable agreement between the workers and management personnel that the workers are having a low degree of influence in different decisions. Again both

the groups have indicated that the desired influence level can be increased to a great extent, particularly at medium and local level. However, in distant level issues though the workers desire to have more influence, the management personnel do not express the desire to increase the workers influence in those issues.

c) Except distant level issues and bonus issues both group desired to have joint decision-making or consultation for arriving at decisions. However, in some issues under these categories also, i.e. like wages and compensation of workers and promotion policy both the groups desired collective bargaining. In distant level issues management personnel feel that those are strictly management prerogative whereas workers views are divided.

d) Joint committees at different levels and workers having equity and representation in the board have been preferred by both the groups as the most desired form of formal participative management. Further, both the groups preferred to have workers representatives in the joint committees rather than union officials/representatives.

e) Workers have shown much desire for effective informal methods and so also management personnel.

f) Inspite of a conducive organizational climate and clarity in the objectives of participative management by both groups, the existing formal participative forums are working at a very low efficiency level mainly due to the limited scope of the committees and non-implementation of unanimous recommendations in time.

Conclusions

The success of the existing joint commitees depends much on the timely implementations of the recommendations and the scope of the committees also. An effective grievance machinery is a must in the organization so that individual grievances may not be the main point of discussions in the joint committees at shop and plant level. Effective communication system and continuous effort to train workers and managers to bring about the attitudinal change are the prerequisites for participative management.

Apart from formal schemes, the management has to give much importance to informal methods like job enrichment, job enlargement, group decision-making, individual counselling etc. so as to change the management style. Multiplicity of trade unions and the political situation of the country are disturbing factors for success of participative management. However, if the informal methods can develop a culture for participative style of management within an organisation, then people will develop faith in the system and formal representative participatlve forums can succeed inspite of different consraints. The informal and formal participative methods are to be treated as supplementary to one another rather than complimentary approaches.

If participative management has to succeed then the whole gamut of decisions rather than matters related to production and welfare only have to be incorporated in the scope of functions of different forums. Further micro level studies at various organization levels is a must to identify the desire for participation in different issues, way of involvement and the preferred form of participation as expressed by management personnel and workers. Government may set the broad guideline but every organization has to formulate its own participative design based on the specific needs and this is really a challenging task for the management. The future of participative management in India depends upon how efficiently the managements of various organizations can meet this challenge.

REFERENCES

Alexander, K. C. *Participative management*. New Delhi : Shri Ram Centre for Industrial Relations and Huma1 Resources, 1972.

Coch, L. & French, J. R. P., Jr. Overcoming resistance to change. *Human Relations*, 1948, 1, pp. 512-532.

Dachler, H. Petor. The problem nature of participation in organisations : A conceptual evaluation. In Bert King, Siegfried, Streufert, and Fred. E. Fiedler (eds) *Managerial control and Organisational Democracy*, New York : John Wiley & Sons, 1978, page 1-16.

Dachler, H. Peter & Wilpert, Bernard. Conceptual dimensions and boundaries of praticipation in organizations : A critical Evaluation, *Administrative Science Quarterly*, 1978, 23 (March), pp. 1-39.

Das, Nabagopal. *Experiments in industrial democracy*, Bombay : Asia, Publishing House, 1964.

———————. *The American idea of industrial democracy.* London: University of Illinois Press, 1970, p. 527.

Hedben, John & Shaw Graham. *Pathways to participation.* London: Associated Business Programmes, 1977, p. 10.

Kennedy, van Dusen. *Unions employers and government: Essays on Indian Labour Questions*, Bombay: Manaktolas, 1966.

Lewin, K. Group decisions and social change. In E. E. Maccoby, T. M. Newcomb & E. L. Hartley (eds) *Readings in Social Psychology*. New York: Holt, Rinehart & Winston, 1947, pp. 197-211.

Marrow, A. J., Bowers, D. C. & Seasore, S. E. *Management by participation.* New York: Harper, 1967.

Mhetras, V.G. *Labour participation in management.* Bombay: Manaktalas, 1966.

Moulder, M. Power equalization through participation. *Administrative Science Quarterly*, 1971, 16(1), pp. 31-38.

Pandit, D. P. *Workers participation in management : The Indian Experience* (Mimeographed report submitted to the Institute of Economic Growth, Delhi), 1962.

Sheth, N. R. *The joint management council : Problems and prospects.* New Delhi: Shri Ram Centre for Industrial Relations and Human Resources, 1972.

Subramanian, K. N. *Labour-management Relations in India.* Bombay: Asia Publishing House, 1967.

Straus, George & Rosenstein, Eliezar. Workers participation : A critical view. *Industrial Relations*, 1970, 9, pp. 197-214.

Thakur, C. P. & Sethi, K. C. Participative management in public enterprises. *Indian Journal of Industrial Relatios*, 1972*n*, 7(4), pp. 615-623.

Walker, K. P. Workers' participation in management : Problems, practice and prospects. *IILS Bulletin* 1974, No. 12, pp. 3-35.

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A Methodology of Materials Planning at the Corporate Level —Case of Coal Mining Industry

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The paper highlights the distinguishing features of materials consumption in mineral industries as also of mining operations. It suggest that there should be a clearly defined output planning 'by age' as a basis for reliable material requirement planning.

There are many well established principles regarding materials planning and management in the manufacturing sector industries. In comparison, there are not many studies on the extractive sector industries to establish any acceptable propositions. The principles of scientific methods of inventory management have not yet reached the mineral industries on any significant scale. The present paper deals with materials planning for the coal mining industry at the corporate level. It has two broad objectives to deal with. The first is to bring out the distinguishing characteristic features of the material inputs consumption in the extractive industries like the coal mining as also to highlight the basic differences between manufacturing and extraction operations. This would indicate the complexities involved in materials planning for the extractive industries. The second is to examine the stability/variability of the annual rate of materials consumption over different operating mines as also to see how the relative importance of each material item (ABC type of relations) varies over mines. The paper also aims at hypothesizing some broad behavioural trends in the material inputs consumption over different age-groups (of mines) and over different stages of mining operations, inputs requirements.

The paper is divided into four sections. Each one deals with specific aspects of the problems of materials requirement planning. The last section estimates the annual materials requirements for the Sixth Plan coal targets under different scenarios.

Coal forms one of the major sources of energy and is a vital input for industrial and agricultural development. Thus the general economy of the country will be affected by the performance of the coal mining industry. The relative position of the coal mining industry in the total industrial economy of India as revealed by its value-added weight is found to be as high as 7.27 per cent as compared with a weight of 1.66 per cent for metallic mining, 0.79 per cent for non-metallic mining and quarrying, and 9.79 per cent for the aggregate mining sector[1]. There are not many empirical studies on India's coal mining industry though it occupies such a prominent place in the economy both in quantitative and qualitative terms.

1.1 Scope and coverage of the study

The study is essentially an empirical one, based entirely on primary data collected through elongated field investigations. The materials consumption data have been collected from account books of the stores department of the coal industry. The study refers to the year 1964-65 which is found to be a normal year with a minimum of intra-year price and wage fluctuations. The study covers 18 bituminous coal mines with a total annual output of 3.131 million tonnes which forms roughly 4.7 per cent of the all-India coal output during the reference year.

These mines are spread over five different coal fields, each lying a couple of hundred miles away from the other. All the 18 mines covered in the study, vary substantially in output size, age, history and natural conditions. The overall unit pit-hand costs (i.e. underground+ surface costs) for these mines is worked out at Rs. 14.25 per tonne of coal raised, out of which an amount of Rs. 3.23 (or 22.6%) is incurred on the cost of material inputs consumption, and the rest is being accounted for by wages cost. For these 18 mines together, the labour and capital input coefficients come out to be 1.66548 and 0.00936 respectively. It may be noted that all the surveyed mines are under the control of a single management and hence, the prices of factor-inputs and managerial effectiveness are same for all the mines. Technology and methods of mining are also found to be similar in all the surveyed mines except in mine Q, which is partially mechanised.

Coal mining industry consumes many and varied kinds of material inputs ranging from local made bamboo thatties and baskets to steel and sophisticated spare-parts. These materials are consumed on production and non-production (overheads) operations. The important material inputs consumed regularly by the coal mining industry comprise timber, iron, steel and other metals, pipes and pipeline fittings, drilling rods and drilling bits, drill spares, steel wire ropes, rails, tubs and tub materials, general tools, hardwares, electrical goods and accessories, cables, electrical machinery spares, oils, paints and varnishes, explosives, caps and caplamp spares, stationery and so on. Some of them are very fast moving and some, not.

1.2 Nature of material inputs consumption

The nature of material inputs consumption in extractive industries differs substantially from manufacturing and agriculture. The material inputs consumption in extractive industries in general and the coal mining industry in particular, has certain peculiar characteristic features that distinguish them from the other sectors. The following are those features :

1) No material input of whatsoever kind enters into and forms part of the final product of the extractive industry. The materials consumption in the mining sector can, therefore, be regarded as the one meant for "repairs and maintenance" of all the fixed capital equipment including the mine itself. If this is so, the materials consumption in the mining sector is a complex phenomenon reflecting the impact of various divergent factors like the operation efficiency of the workers, age distribution of the equipments and of the mine, diversified geological factors and so on.

2) As the mining operations (workings) have an inherent tendency to move continually into different directions, there will be frequent breakages of machinery and other related equipments. Repairs and maintenance, therefore, becomes a significant and regular process, involving a sizeable consumption of various material inputs and spares. For the mineral industries inventory (or materials) management means essentially spare parts management.

3) In the underground mining operations, water springs up and accumulates in huge quantities. The problem of corrosion, therefore, assumes special dimensions in the mineral industries. The extent of water logging in a mine will have a major impact on the magnitude and structure of materials consumption.

All the above distinct features of mining operations call for a specialized methodology (for materials planning). Further, it has been observed that overhead costs form as high as 40.7 per cent of the total costs in the coal mining industry[2]. Material needs to maintain overhead infrastructures are different from those of the mining operations. Therefore, the materials requirements planning should be separately prepared-one for the overheads and the other for the mining operations.

1.3 Composition of production costs by "Materials" and Wages

Coal mining industry is known to be a labour-intensive one, not only in India but in many other coal producing countries also. This is clearly reflected in the structure of its production costs by wages and materials. The data regarding this aspect is given in Table 1 which covers 22 coal mines with an output of 3.651 million tonnes. It reveals that the proportion of materials cost per tonne in the total unit production cost is very low (only 28%) as compared with the wages cost component.

If one takes into account only the pit head costs i.e., underground plus surface costs, then the proportion of material costs in the pit head costs goes down to 20 per cent (for 22 mines). The same proportion is worked out to be 23 per cent for the 18 mines under study. The pit head costs defined as above are the direct costs which cover all the current expenditure incurred upto the point of coal raisings being reached to the pitmouth from the underground workings. It would be noted that the pit-head cost as defined here does not include the costs incurred on workshops, coal screening and electricity consumption which together are termed as Departments Costs in Table 1.

The structure of production costs indicates, on the one hand that the coal mining industry is relatively less dependent upon the manufacturing other sectors of the country, and on the other, that the value added component per unit of output is relatively high in this industry. Comparatively, the materials cost component in total production costs in the manufacturing sector as a whole is estimated to be around 60 to 70 per cent. And, in the case of processing industries like oil refining, it goes still further up, to about 80 to 90 per cent. Therefore, it is obvious that the value-added per unit of output is much lower in the case of manufacturing sector than in the extractive sector. In addition, the extent of inter-industry dependence is also more. These differences may have to enter into the planning for materials and the levels of inventories to be maintained, in the respective sectors.

Table 1

Production Cost Composition By Wages And Materials

Sl. No.	Cost category	Unit operating cost (Rs./Tonne)					
		Wages Rs./Tonne	%	Materials Rs./Tonne	%	Total Rs./Tonne	%
1.	Underground costs	9.50	58.5	2.91	17.9	12.41	76.4
2.	Surface costs	1.22	7.5	0.32	1.9	1.54	9.4
3.	Department costs	1.01	6.2	1.29	7.9	2.30	14.1
4.	Total cost	11.70	72.0	4.54	28.0	16.25	100.0

Note : The data presented in the above table covers 22 Coal mines with a total annual output of 3.651 million tonnes.

In this section an attempt is made to analyse the changes in the relative importance of each material class over different mines, apart from giving the mine-by-mine structure of the annual rate of materials consumption along with its stability/variability. This section also makes a few observations regarding the changes in the proportion of material costs in pithead costs. It also brings out the implications for materials planning.

2.1 Method of computing the per unit materials requirements (or the input-output coefficients)

The common procedure of estimating the annual rate of materials consumption for the coming year is to project its past trends. This may not give reliable estimates particularly if there is capacity expansion, or improvements in the rate of capacity utilisation and also if there is a change in the product-mix. As an alternative, input-output ratios are also used in this regard. In the present paper the input coefficient is computed as the ratio of materials in the value terms to the unit of coal output (tonne). Physical output has been taken as the denominator, instead of value of output. This has been chosen because of the fact that the materials input consumption does not depend much on the quality of coal raised, whereas, the value of output depends upon the price and consequently upon the quality. Therefore, the input coefficient calculated as the ratio of value of input to value of output, will have either a downward or an upward bias depending upon the quality of coal raised. To get rid of this bias, it has been decided to compute the ratio in the above fashion. However, the material inputs are retained in value forms to facilitate the additivity of different products consumed in the industry. The sum of the individual coefficients will give the annual rate of materials consumption per tonne. By multiplying this with the total or the targetted output, one can get the total value of per annum materials consumption or requirements.

2.2 The structure of complementary materials consumption on the maintenance of overhead infrastructure

Complementary or non-production material inputs are those that are consumed in non-production operations like overheads. We have noticed earlier that the overhead costs form a sizeable segment (40%) in the TAC of the industry. Accordingly, the coal mining industry consumes huge amounts of material inputs on the repairs and maintenance of its overhead infrastructure. This overhead input structure for the aggregate industry comprising five coal fields is given in Table 2. In the present study, the total material-input bill on this count is found to be Rs. 1.18 per tonne which accounts for roughly 26 per cent of the total materials bill (i.e. production plus non-production materials bill) paid by the industry.

Table 2 gives the per tonne annual rate of materials consumption on overheads maintenance by various materials classes. The percentages and ranks given there indicate the relative importance of each materials class in the total consumption basket. Table 2 reveals that the major material inputs that go into the regular maintenance of overhead infrastructure are "oils, paints and varnishes," 'iron, steel and other materials," ' "consumable stores", and "motor car and lorry spares' . These four coefficients together form as high as 60 per cent of the total materials-bill paid towards the maintenance of overheads. "Oils, paints and varnishes" alone account for about 20 per cent of the total annual materials bill. The other principal inputs are "electrical goods and accessories", "stationery" and "timber" which together form a little less than 78 per cent of the total annual materials-bill incurred on overheads. These materials go mainly into the repairs and maintenance of "transport equipment", "office buildings" and the "township". The other less important items like "pipes and pipelines fittings", "cables", "mineral prospecting materials" and "hardwares" together account for about 13 per cent. The remaining 9 per cent is accounted for by other items. Knowledge about the relative importance of various material items (in value terms) will help in exerting rational control over procurement, issues, stock level maintenance, etc.

It may be noted that the material input structure incurred on the maintenance of overhead infrastructure is independent of the normal production laws, or in other words, of the generally used concept of input-output norms. Further, it is also independent of the scale of operations, level of technology, methods of mining, geologi-

Table 2

The Structure of complementary materials input consumption in The Coal Mining Industry on the maintenance of overhead infrastructure

Sl. No.	Material class	Input Coefficient (Rs./Tonne)	% to total	Rank
1.	Timber	0.0600	5.08	8
2.	Iron, Steel & other metals	0.1728	14.65	2
3.	Pipes & Pipeline fittings	0.0415	3.51	9
4.	Cables (Electrical)	0.0274	2.32	11
5.	Coal drill spares & rails	0.0177	1.50	13
6.	Electrical machinery spares	0.0175	1.48	14
7.	General tools	0.0150	1.27	15
8.	Hardwares	0.0187	1.59	12
9.	Consumable stores (sundries)	0.1704	14.45	3
10.	Electrical goods & accessories	0.0866	7.35	5
11.	Tubs & tub materials	0.0103	0.87	16
12.	Oils, paints & varnishes	0.2344	19.87	1
13.	Explosives	—	—	—
14.	Steel wire ropes	0.0299	2.53	10
15.	Stationery	0.0628	5.32	7
16.	Motor car & lorry spares	0.1476	12.51	4
17.	Mineral prospecting materials	0.0672	5.69	6
18.	Cap lamps and their spares	—	—	—
	Total materials-bill	1.1798	100.00	

cal factors, etc. This is mainly because of the fact that the structure and the magnitude of overheads are generally guided by and adhere to the non-production laws like the attitudes of the management, profitability, age of the industry, influence of the institutional factors like the trade unions, government policies and so on. So also the inputs incurred on overheads. The magnitude of these coefficients (or the annual rate of materials consumption) depends upon the magnitude of the overhead infrastructure that the industry decides to maintain. Therefore, the magnitude of the overhead input coefficients is mainly a matter of policy.

A comparison between Table 2 and Table 3 shows that the structure of materials consumption on overheads is distinctly different from that of the one on the extraction operations. This kind of decomposition of materials consumption between overheads and extraction operations helps the estimation of the

materials requirements more accurately.

2.3 Materials consumption pattern on extraction operations (at all-industry level)

Per tonne annual materials consumption by various classes of materials have been computed for 18 coal mines and aggregated for the industry in Table 3. The input coefficient gives the extent of demand generated by a tonne for materials from other sectors. It also gives the extent of dependence or linkage of coal mining with other sectors.

It is evident from Table 3 that 'explosives' is the single largest input consumed in the coal mining industry. Its coefficient works out to 1.2591 which forms 39.03 per cent of the total per tonne materials-bill. Next is "Timber" with its coefficient at 0.3178 (9.85%), followed by "Steel wire ropes" and "tubs and tub materials" with 0.2786 (8.63%) and 0.2497 (7.74%) respectively as their input coefficients. These four material inputs are 'vital' in the mining operations, and together form as high as 65.3% of the total material input-bill. All these four inputs go mainly into the 'Key' mining-processes whose performance determines the the over a l performance and efficiency of a mine. Explosives are used in blasting to dislodge the coal from the seam, timber in supporting the roof in decoaled areas, while 'steel wire ropes' and 'tubs and tub materials' are used in hauling the extracted coal to the surface.

"Caplamps and their spares" comes next in importance with coefficient at 0.2488 (7.72%) followed by "coal drill spares and rails", consumable stores," and "oils, paints and varnishes" These four coefficients together account for 21.6% of the total materials-bill. The materials of "caplams and their spares" go mainly to provide safety to miners. Its coefficient is high because the industry is a labour-intensive one, 'Coal drill spares' are used in the coal-cutting operation which uses drilling machines to drive the holes on the coal seam. Rails are used in hauling operation. "Consumable stores" and "oils, paints and varnishes" go into the general run of the mining machinery and equipments.

"Hardwares" comes next with coefficient at 0.0575 which constitutes 2.36 per cent of the total materials-bill. This is followed by "iron, steel and other metals", "machine-mining spares" and "electrical goods and accessories". These four coefficient together form 8.3 per cent of the total materials bill.

Minor material inputs like "pipes and pipeline fittings", "cables", "stationery", "general tools"and "electrical machinery spares" constitute only 4.9 per cent of the total materials-bill.

The total materials-bill has been summed up to be Rs. 3.2260 per tonne which forms 22.6 per cent of the pithead costs. The structure of materials consumption as discussed above will give some guidelines regarding the control of various materials at the stores level.

The labour input coefficient for all the 18 mines together has been found to be 1.6665. Labour inputs are measured in terms of aggregate mandays incurred during the year in raising the coal output of that year. The labour-input coefficient is calculated as a ratio of total mandays to total output. This is a physical proportion which may have a serious limitation of ignoring the distribution of labour skills and their age over different mines. However, it is assumed that the labour skills are homogenously distributed over different mines. Similarly, a homogenous 'managerial effectiveness' is also assumed for all the mines.

The capital input coefficient for all the 18 mines together has been worked out to be 0.0094. Capital inputs in a mine are measured in terms of the aggregate horse-power installed on various mining operations. This does not take account of the ancillary equipments installed in a mine. Further, the surface installations like coal bunkers, screening plants, water reservoirs and so on are also ignored. Nevertheless, it gives an idea on the extent of inter-mine variations in capital inputs. The capital input coefficient is computed as a ratio of capital-inputs, as measured above, to total annual output.

2.4 Inter-mine variations in input-output ratios

Critical assessment of the stability/variability of the input coefficient in the coal mining industry is very important. Knowledge about the stability of input structures, stable over different mines' would be useful in estimating

Table 3

Composition of material inputs consumption in The Coal Mining Industry, along with Means, S.D's and C.V's of input Coefficients

Sl. No.	Materials Class	Input Coefficient			Mean	S.D.	C.V. (%)	Rank of C.V.	Input coeff. differential
		Rs./Tonne	% to total	Rank of coeff.					
1.	Timber	0.3178	9.85	2	0 3085	0.1436	46.53	8	7.03
2.	Iron, steel & other metals	0.0667	2.07	10	0.0697	0.0270	38.69	13	5.36
3.	Pipes & Pipeline fittings	0.0567	1.74	13	0.0620	0.0559	90.18	2	38.13
4.	Cables (Electrical)	0.0430	1.31	14	0.0415	0.0324	78.08	4	36.87
5.	Coal drill spares & rails	0.1674*	5.19	6	0.1745	0.0719	41.20	11	4.68
6.	Electrical machinery spares	0.0186	0.57	17	0.0188	0.0087	46.27	9	6.03
7.	General tools	0.0187	0.57	16	0.0192	0.0045	23.33	20	2.28
8.	Hardwares	0.0757	2.36	9	0.0584	0.0491	84.05	3	15.12
9.	Consumable stores (Sundries)	0.1667	5.17	7	0.1760	0.0682	38.74	12	5.21
10.	Electrical goods & accessories	0.0578	1.79	12	0.0559	0.0151	26.94	18	2.87
11.	Tubs & Tub materials	0.2497	7.74	4	0.2521	0.1481	58.70	5	11.90
12.	Oils, paints and varnishes	0.1121	3.47	8	0.1127	0.0545	48.41	7	20.53
13.	Explosives	1.2591	39.03	1	1.3891	0.4288	30.87	15	3.37
14.	Steel wire ropes	0.2786	8.63	3	0.2529	0.1248	49.35	6	5.29
15.	Stationery	0.0222	0.69	15	0.0241	0.0871	29.64	16	3.308
16.	Machine mining spares	0.0663	2.06	11	0.0364	0.0749	205.92	1	—
17.	Cap lamps & their spares	0.2488	7.72	5	0.2680	0.1013	37.78	14	4.45
18.	Total materials input-bill	3.2260	100.0	—	3.3200	0.5637	17.00	22	1.68
19.	% of (18) in production costs	22.62	—	—	23.93	4.46	18.60	21	1.96
20.	Labour-input coefficient	1.6655	—	—	1.6162	0.4505	27.87	17	2.60
21.	Capital input coefficient	0.0094	—	—	0.0093	0.0039	42.18	10	4.31
22.	Electricity	1.0388	—	—	1.0250	0.2404	23.45	19	2.54

NOTES : S. D.=Standard Division; C.V. Coefficient of Variation; C.V. is computed over 18 mines.
*Roughly 50% of this amount is occupied by rails alone.

the inputs requirements of the coal industry. In turn, these estimates, if they are reliable, would be useful for the supplying industries in planning their production capacities and annual output targets.

It is difficult to expect the same stability as is found in the case of manufacturing industries, because each mine operates under different sets of widely varying natural and working conditions. The mines under study vary substantially in size, age, history and natural conditions.

Because of the large variability in the natural setting and the geological handicaps, equal amount of inputs of labour, materials and capital, will produce unequal results in terms of output. This would create a number of problems in making the materials requirements planning for coal sectors. The second half of Table 3 gives the extent of inter-mine variations in the coefficients. For this purpose the coefficient of variation (C.V.) over 18 mines has been computed. In addition, input-differential (i.e. maximum divided by minimum) for each coefficient has also been computed. It is observed that the magnitudes of C.V. and the input-differentials move together in the same direction. The range of variation of the input coefficients is summarised below :

Sl. No.	Range of C.V*	Coefficients
1.	Less than 25	General tools, total material inputs bill, and % of material-bill in production costs.
2.	26-40	"Iron, steel and other metals", consumable stores, electrical goods and accessories, explosives, stationery, caplamps and their spares, and labour coefficient.
3.	41-55	Timber, 'coal drill spares and rails', electrical machinery spares, oils, paints and varnishes, steel-wire ropes, and capital coefficient.
4.	56-70	Tubs and tub materials.
5.	71-90	Pipes and pipelines fittings, cables and hardwares.
6.	above 90	Machine mining spares.

* C.V. = Coefficient of variation in %.

It can be assessed from Table 3 that the material input coefficient numbering six that fall under the C.V. range of 26-40 account for about 56 per cent of the total materials bill paid by the industry. The major material inputs that go mainly into the underground coal hauling operations viz., 'tubs and the materials' and 'steel wire ropes' together form as high as 16.4 per cent of the total materials bill.

These two coefficients show relatively large amounts of variability at 58.7 per cent and 49.4 per cent respectively. Comparatively, the largest single input in the total inputs package viz., explosives, and the coal drill spares that together go solely into the coal-cutting process exhibit relatively less amount of variation at 31 per cent and 41 per cent respectively. These two coefficients together form as high as 41.6 per cent of the total materials bill.

The input coefficients of 'pipes and pipeline fittings', 'cables' and 'hardwares' show extremely large amounts of variability with a C.V. around 80 per cent. These three coefficients together form only 5.4 per cent of the total materials-bill.

As against the variations in individual input coefficients over mines, the study reveals that there is a relatively low variability (a C. V. of only 17%) in the 'total material input-bill' of the mines. It is, therefore, the structure of inputs (or input-combinations) that varies over mines, and not the total per tonne material inputs consumption. Further it can also be observed that the "proportion of material cost" in pithead costs does not vary much. Its C.V. is only 18.6 percent. These are the two basic notable points in the study that will have a vital role in materials planning because of their high productive value.

The extent of inter-mine disparties in the labour-input coefficient is considerably high. Its C.V. is found to be 28 per cent. On the other hand, the capital-input coefficient exhibits a larger amount of variation with a C.V. of 42 per cent. This is mainly due to larger inter-mine differences in the structure of mining operations.

On the whole, the study reveals that the per tonne requirements of the factor-inputs vary widely from mine to mine. This has been

equally reflected in both the C.Vs of the coefficients and their differentials. Reasons are many and varied. Between the labour and material nput which together constitute the current operating costs, the total material-input bill is almost stable over mines while labour inputs vary widely. Though the per tonne material-input bill is almost stable over mines, the individual input coefficients vary widely. It should be remembered that the factor-input prices, technology and methods of mining are same in all the mines. Under these conditions, if the input-output coefficients are to be stable over mines the mines should also be stable with respect to the structure of their respective mining operations. The later one is an impossibility in the coal mining industry and hence, the former is also impossible. In conclusion, it can be stressed that a stable input structure, stable over mines, is an incompatible proposition for the coal mining industry. There arises a need to find out some meaningful behavioural trends which can be used in the estimation of materials requirements. This will be taken up in a later section.

2.5 Mine-by-mine input structures

Mine-by-mine input structure are given in Table 4 in which all the coefficients are expressed in terms of percentages to their respective totals. It gives the relative importance of each material class in the total materials consumption basket. ABC analysis also gives the same thing but at a still more disaggregative (stores) level. It is evident that the relative importance of each material class changes from mine-to-mine. This is the peculiar features of the extractive industries. In more clear terms, it can be said that an "A" class item of one mine may be a "B" class item or even a "C" class item for the other. In terms of VED analysis, it can also be said that a "vital" item for one mine may become an "essential" or even "desirable" item for the other. Further, the relative importance of various materials in value terms across mines changes mostly with the length of underground hauling distances. Similarly, age of mines and the stage of mining operations will also exert a significant influence on the relative importance (or the structure) of various materials consumed by the coal mining operations.

From Table 4 it is clear that the relative importance of each material undergoes significant changes from mine to mine. Therefore, no uniform control over materials is possible in the case of coal mining.

2.6 Proportion of materials cost in 'High-cost' and 'Low-cost' bearing mines

It can be noticed from Table 4 that all the high-cost bearing mines like R,S,T,M,L and P mines have relatively low proportions of total material input costs in their respective pit-heads costs. On the other hand, these mines have slightly higher levels of labour-input coefficients. An opposite situation can be observed in the case of low-cost bearing mines. This is broadly the divergence in the structure of pithead costs between high-cost and low-cost bearing mines. From this pattern, it can be inferred that it is the wages bill, and not the materials bill, that contribute more towards increasing costs in the coal mining industry. This can further be supported by the fact that the total materials bill is almost stable (as seen earlier) over mines while the labour coefficient varies widely. The structure of costs between wages and materials varies from mine to mine with a given technology and mining methods, because of a corresponding variation in the structure of mining operations in each mine. Comparatively, one can expect a stable structure of production costs in the case of manufacturing firms if the technology and methods of production are the same over firms.

It has been observed that there are large amounts of variability/instability in the input coefficients. Thus, the predictive value of the coefficients is very much reduced and thereby, the reliability of the estimates of the annual rate of materials requirements will also be equally reduced. From predictive point of view, the coefficients cease to have much significance. An attempt is made to find out some broad behavioural trends in the coefficients on the basis of which a method for estimating the material requirements is suggested.

3.1 Distinguishing features of the mining operations

Mining operations are characterised by the following distinguishing features :

i) Extraction or mining activity is inhere-

Table 4

Mine-by-mine structure of material input consumption*

Sl. No.	Materials Class	Mine R	Mine S	Mine E	Mine T	Mine M	Mine L	Mine P	Mine F	Mine N
		Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %
1.	Timber	9.04	11.49	8.73	15.02	13.57	20.28	18.46	10.94	16.69
2.	Iron, Steel & other metals	2 25	2.24	2.41	2.75	1.56	1.20	2.20	3.80	1.33
3.	Pipes & Pipeline fittings	1.98	1.85	4.89	0.86	0.29	2.57	0.97	1 84	1.80
4.	Cables (Electrical)	3 33	0.41	0.74	0.52	0.90	0.47	1.23	0.09	1.29
5.	Coal drill spares & rails	4.60	3.21	6.76	2.98	5.54	8 02	2.74	9 12	4.57
6.	Electrical machinery spares	0.42	0.41	0.80	0.64	0.39	1.03	0.84	0.80	0.50
7.	General tools	0.64	0.49	0.56	0.31	0.61	0.72	0.63	0.50	0.44
8.	Hardwares	3.23	1.63	1.13	2.82	1.26	0.67	2.10	1.56	1.28
9.	Consumable stores (sundries)	3.45	3.43	8.47	4.27	8.18	7.56	4.39	5.22	6.95
10.	Electrical goods & accessories	2.00	1.36	1.11	2.29	1.47	2.47	2.83	0.89	1.05
11.	Tubs & tub materials	8.97	1.62	5.54	1.89	6.18	4.17	14.38	9.12	4.78
12.	Oils, paints & varnishes	2.71	2.54	3.30	2.72	5.10	3.32	4.35	1,79	4.52
13.	Explosives	37.20	57.49	36.73	52.85	27.72	28.27	25.02	32.21	35.00
14.	Steel wire ropes	8.51	4.05	10.15	2.62	18.34	9.89	11.09	13.93	11.33
15.	Stationery	0.49	0.63	0.61	0.65	0.52	0.51	0.56	0.66	0.61
16.	Machinery mining spares	0.70	1.26	0.43	0.53	—	0.33	0.38	0.28	0.75
17.	Cap lamps & their spares	10.45	5.88	7.63	6.29	8.38	8.63	7.82	7.24	7.16
18.	Total material-input bill	100.00	100.00	100.00	100.00	100 00	100.00	100.00	100.00	100.00
		(3.436)	(3.794)	(4.906)	(3.621)	(2.533)	(2.335)	(2.587)	(3.329)	(3.032)
19.	Per Tonne pithead costs (Rs.)	18.79	18 25	17.80	16.18	15.52	15.17	14.32	14.31	13.83
20.	% of materials cost in pit-head costs	18.28	20 78	27.56	22.32	16.32	15.33	18.05	23.26	21.92
21.	Labour input coefficient	2.425	2.282	2.378	1.989	1.896	1.898	1.693	1.659	1.843
22.	Capital input coefficient	0.01349	0.01416	0.01578	0.01637	0.01092	0.00894	0.01516	0.00700	0.00915

Sl. No.	Materials Class	Mine C	Mine D	Mine H	Mine J	Mine Q	Mine A	Mine B	Mine C	Mine O
		Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %	Input Coeff. %
1.	Timber	5.97	3 68	8 52	9.63	4.87	4.70	4.85	4.58	2.65
2.	Iron, steel & other goods	1.87	1.98	2.15	2.39	2.31	1.54	0,74	1.93	2.51
3.	Pipe & Pipeline fittings	0.18	0.95	3.42	0.17	1.11	1.63	2.11	4.16	0.90
4.	Cables (Electrical)	0.42	1.91	1.70	0.33	2.20	2.34	1,04	0.35	3.14
5.	Coal drill spares & rails	7.58	6.75	6.50	5.03	2.98	4.60	4.81	4.05	4.16
6.	Electrical Machinery spares	0.93	0.79	0.52	0.50	0.45	0.24	0.38	0.20	0.34
7.	General tools	0.48	0.64	0.67	0.52	0.57	0 66	0.62	0.30	0.76
8.	Hardwares	0.82	1.25	1.07	1.47	7.26	1,03	0.98	0 98	1.10
9.	Consumable stores (sundries)	4.01	5.41	3.98	5.55	2.46	6.34	5.07	4.77	6.39
10.	Electrical goods & accessories	1.53	1.68	1.57	1.54	2.63	1.69	1.85	1.25	1.78
11.	Tubs & Tub materials	17.38	9.36	19.90	9.13	8.64	6.02	7.28	10.63	1.79
12.	Oils, paints & varnishes	3.71	2.36	2.87	2.14	3.73	3.26	2.55	1.49	10.46
13.	Explosives	45.22	47.20	42.37	51.75	35.32	48.45	49 08	45.79	43.10
14.	Steel wire ropes	4.15	5.24	9.08	3.96	7.72	6.88	6.63	2.81	4.37
15.	Stationery	0.82	0.99	0.76	0.96	0.70	1.06	0.72	0.64	1.02
16.	Machine mining spares	0.17	0.18	0.24	0.29	10.39	1.52	1.59	0.67	—
17.	Cap lamps & their spare	4.76	9.65	3.68	4.64	6.57	8.04	9.50	15.19	16.02
18.	Total material input-bill	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
		(3.509)	(3.695)	(3.797)	(3.039)	(3.249)	(3.474)	(3.192)	(3.263)	(2.918)
19.	Per tonne pithead costs (Rs.)	12.95	12.88	12.64	12.58	12.46	12.43	11.68	11.55	10.95
20.	% of minerals cost in pithed costs	27.14	28.68	30.11	24.55	26.09	28.02	27.32	28.25	26.64
21.	Labour input coefficient	1.402	0.954	1.347	1.176	1.413	1.079	1.389	1.231	1.058
22.	Capital input coefficient	0.00633	0.00700	0.00380	0.00535	0.00743	0.00730	0.00496	0.00549	0.0082

* Mines have been arranged in descending order of their unit cost levels. Unit costs refer to pithead costs comprising underground and surface costs.

NOTE Figures in brackets show the per tonne total materials input costs in Rs.

ntly "shifting" in nature. The extractive operation cannot be undertaken in a single concentrated place as in the case of a manufacturing firm. When a tonne of coa lis extracted it creates a void created by the earlier tonne extracted. Therefore the workings (also called as working faces) have an inherent tendency to "shift" continually into different directions, thus enhancing or reducing the lengths of the underground hauling distances. Similar is the case with the factor input requirements. It should be noted that the longer hauling distance means the larger amounts of factor inputs consumption per tonne raised, and vice versa. This observation contributes to and underlies most of the generalisations arrived at in this study.

ii) A coal mine is considered more as a "transport undertaking" than an "extractive" one. This can be justified on the ground that the proportion of underground hauling costs in the total pit-head costs is very high. Only a small proportion of the workers and other factor inputs are employed directly at the face on purely "extraction" work. Most of the factor-inputs are employed away from the face mainly in the transport of materials, men and power, etc. In addition, the hauling distance has a vital role to play in the analysis of the inter-mine variations in unit costs and factor inputs consumption.

iii) A coal mine, like a manufacturing firm, is not a single unit of operation, but a multiple-unit operative system. This can be substantiated by the fact that there exists a statistically significant functional relationship between the total output of a mine and the number of working faces.[3] (See also columns 5 and 10 of Table 5).

The operating unit in a mine is called the working face. Each one is distinct and separately identifiable factor input structure. There will be many working faces operating simultaneously under the same roof of a mine. They are necessarily scattered over different areas in a mine and thus, they have a distribution by distance from surface. The nature of this distribution will have a significant influence on the magnitude and structure of unit operating costs and materials consumption/ demand pattern.

iv) To ensure safety and conservation, the major mineral industries generally follow the scientific methods of mining. The industry that has been surveyed for this study, follows the popular "Board & Pillar" method. In this method, the spread of working faces follows a pattern either through time or through different output scales, or both.

v) Mineral resources (including coal) are essentially characterised by exhaustibility, non-replenishability or non-renewability, and are hidden too. Mineral resources are 'hidden and unknown' both in quality, quantity and mineability. Exhaustibility makes a mine extinct and non-renewability makes this certain and also gives a caution for reckless mining, or in other words for conservation, while "hidden nature" injects a high amount of "risk and uncertainty" into the gamut of mining operations.

The above characteristic features through (ii) are inter-connected. They underly all the behaviouristic models pertaining to the coal mining industry. They will have also an impact, either directly or indirectly as also either individually or jointly, on the magnitude and the structure of annual rate of materials consumption. Because of "shifting" nature of the mining operations, each additional tonne has to cover a longer/shorter distance from surface, consuming varied quantities of factor-inputs per tonne raised. In other words, unit factor-input requirements (materials, men and money) vary for each additional tonne raised.

3.2 The structure of mining operations and the factor input requirements

The distinguishing features of mining operations, give rise to structural differences

Table 5

Changing structures of mining coperations over different age-groups
(In tonnes of indices with the first age-groups as base)

Sl. No.	Age group (in years)	No. of mines	Output		No. of working faces per mine	Total undergroud hauling distance per mine	Hauling distance per working face	Hauling distance per tonne raised	Output per working face (face mine)	Output per mine (mine size)
			'000 tonnes	%						
1.	Under 2	4	107.8	2.95	=100	=100	=100	=100	=100	=100
2.	2—4	6	696.7	19.08	216.6	406.1	187.4	94.2	198.9	431.0
3.	5—7	2	367.1	10.05	383.3	925.7	241.4	135.8	177.7	681.3
4.	8—10	4	565.9	15.50	358.3	1197.1	334.1	227.9	146.5	525.1
5.	11—13	2	727.0	19.90	583.3	1958.1	335.8	145.1	231.3	1349.3
6.	17—19	1	458.6	12.56	700.0	2093.7	299.1	123.0	243.1	1702.0
7.	24 & above	3	728.7	19.90	443.3	1150.4	250.9	127.7	202.1	901.0

NOTE : For mine-by-mine structure of mining operations, See Ch. II of the author's unpublished thesis.

among various mines within a coal field as also among different coal fields. Further, they also generate structural changes in regard to the mining operations within a mine itself. All these changes take place either through time or through the consecutive cumulated output levels. "Structural differences" refer to the engineering/ technical phenomena reflecting the widely varying natural and working conditions under which the mines operate. They also refer to the structure of mining operations maintained by a mine, comprising the number and size of working faces, their distribution by distance from surface, underground hauling distance per tonne raised, and so on.

Changing structures either in a mine or in a coal-field, are the result of cumulated effects of workings during the past periods. The structural differences among the mines are indispensable because of the distinguishing factors (i) through (v) as explained earlier in section 3.1. The net effect is that a mine becomes highly unstable (either over different output scales or through time) with regard to its structures of mining operations. This is reflected in the per tonne underground hauling distance of each mine. If the per tonne hauling distance is the same in two mines, then the per tonne inputs consumption should also remain the same over the two mines. But this is not generally the case, because different mines will be operating at different depths. Added to this, even an individual mine operates continually at different depths both over different points in time and through different output scales. A stable input structure, therefore, is an incompatible proposition for the coal mining industry. Instability is ingrained in the mining operations and therefore, in the input-output relations. This is further accentuated by the divergent natural factors under which mines operate.

As 'age' is a catch-all variable in the mineral industries, all the mine-by-mine structures of mining operations have been summarised in relation to different age-groups and presented in Table 5. Age reflects the effects of cumulated outputs of the past periods. Structural changes are a necessary phenomenon due to the 'shifting' nature of the mining operations. These structural changes exhibit a clear pattern (behavioural) through time age. They will also have a similar impact on the structure of costs and inputs consumption. It is observed that each mine becomes distinct, unique and incomparable over different age-levels (See Table 5). Each age level has its own distinct and unique structure of mining operations and also its own mining/ operational problems. Further there also takes place a shift in the stages of mining operations, (from development to depillaring). Each mine has to face all the specific problems as well as the specific structure of mining operations associated with each age-level.

Table 5 shows how a coal mine behaves in regard to its expansion of physical structure through its life span. Major factors considered in Table 5 to reflect the changing structure of mining operations through age/time are : a) Number of working faces; b) total underground hauling distance per mine; c) Hauling distance

per working face; d) Hauling distance per tonne raised; e) Output per working face (or face-mine); and f) Output per mine (or mine-size). The data for these factors have been generated from the mine layouts or pitmouth. The hauling distance shows the distance to be travelled by a tonne or coal raised to reach the surface as also the factor inputs to reach the working face from the surface. Factors (a), (e) and (f) refer to the growth of size of mining operations in a mine while the factors (b), (c) and (d) reflect the changing (or rather continuously moving) spatial distribution of workings in a mine. All these factors together constitute the structure of mining operations. It can be found that there is a distinct structure for each age level.

It is evident from Table 5 that the indices showing the growth of size of mining operations (viz. factors (a), (e) and (f) exhibit on inverted U-shaped pattern over the age of mines.[4] All these indices reach their respective peaks (with a continuous rising trend) in the age group of 17-19 years, after which they stage a decline. The decline of these indices in the last age-group is essentially due to, what we called, the "depletion-effect". In other words, the size of mining operations cannot be expanded during the last phase in the life span of a mine because the coal deposit will be on the verge of being exhausted. In addition, the old age problems of a mine (like roofing, flooring, dewatering, etc) impose a major constraint on expansion.

The other indices in Table 5 showing the changing distribution of workings by distance from surface (viz. factors (b), (e) and (d)) exhibit similar behavioural patterns over age as the earlier ones, except factor (d) which refers to the 'hauling distance per tonne raised'. Instead of showing a decline in the last age-group, factor (d) registers a rise. This is partly due to the depletion-effect and partly due to the extraction of 'barriers' and other left-over coal for roof support which is generally scattered over longer distances from the surface. Factor (b) particularly indicates how a coal mine gets expanded (in area) due to the voids created by cumulative outputs through age.

The changes in the structure of mining operations through age will produce similar and corresponding changes in the structure and magnitude of materials and other inputs consumption. As there is a unique structure of mining operations for each age levels, there will also be a unique input-structure at each age level. In other words, a tonne raised at different depths or from different age-level need a distinct/ different basket of materials and other inputs consumption. This is presented in the following section.

3.3 The structure and behaviour of materials input consumption over different age-groups (or age of mines)

The structural variations (physical) that the mines undergo through age have a major impact on inputs consumption because of a positive relation between hauling distance and inputs consumption. The evidence in this regard is presented in Table 6. An index is constructed with the first age-group as base to bring out the trends in inputs consumption over different age-levels. While reading Table 6 it is better to consult Table 5 to get the supportive and casual evidence. Before going into these aspects, it may be noted that all the changes of any kind take place only during the finite life span of a mine. The coal miners have reported that the life span of a coal mine normally ranges between 30 to 40 years. Of course, it depends upon a number of factors like the annual rate of recovery, the magnitude of the deposit, the mineral-bearing area, the number of workable seams, the fertility of a mine and so on.

Table 6 gives the weighted average input-output ratios for each age-level. The total per tonne materials consumption, labour and capital coefficients are also given. It is evident from Table 6 that the total per tonne materials bill exhibits a continuous rising trend upto the age-group of 8-10 years after which it shows a declining trend. The index reaches a maximum of 117.7 in the age-group of 8-10 years and then it dips down to 87.4 in the age-group of 11-13 years, followed by a further decline to 73.2 in the last age-group. During the intervening age-groups, there exists, therefore, an inverted U-shaped relationship between the age of a mine and the total per tonne materials consumption.

The labour-input coefficient follows a similar pattern as the above one, but it musters a rise in the last age-group because of the impact of depletion-

effect. The depletion-effect should be understood as the inability on the part of the old mines either to increase the output levels that can be sustained for some more years to come or to maintain the earlier output levels. This inability occurs due to the exhaustion of the deposit. This is the reason why mine-size declines in the last age-group (see Table 5). Added to this, the old mines have to face many adverse mining conditions. There cannot be a proportionate reduction in the labour inputs due to institutional and cost rigidities on the one hand, and due to longer hauling distances per tonne, on the other. Therefore, the labour coefficient rises in the last age-group giving rise to an N-shaped relationship with the age of a mine.[5] The capital coefficient also follows the same trend as the labour coefficient.

The proportion of materials-bill in the total per tonne pit-head costs follows an altogether different, perhaps unique, trend. It continuously declines from the first age-group to the last, except for a marginal rise to the age-group of 11-13 years. This exception occured because of partial mechanisation in mine Q. The above finding is in consonance with the observation made earlier that all the high-cost bearing mines have a lower proportion of materials cost.

The individual material input-coefficients also exhibit some broad behavioural trends over various age-levels. Most of them follow the same pattern as the one followed by the total per tonne materials input-bill. In other words, they bear an inverted U-shaped relationship with the age of mines. Many of the individual material coefficients reach a maximum in the age of 8-10 years after which they stage a decline. About all the indices in the last age-group are lower than the ones in the first-age-group.

Thus, the inverted U-shaped relation is found. The principal exception to this trend is the 'timber' coefficient which reveals a steadily increasing trend all through the age-groups. Notably, there is no fall in the last age-group because the coal seam becomes structurally loose with cracks and fractures due to old age, giving rise to acute roofing problems. Similar is the case with the coefficient of "steelwire ropes" which does not register a fall in the last age-group because the old mines may have to extract the 'barriers' left out in the far off places. There is yet another exception i.e , the coefficient of "oils, paints and varnishes" which does not fall in the last age group. This is because of the old age of equipments and machinery. The behavioural trends of the input coefficient through time/age are fairly consistent with the trends in the structure of mining operations that the mines undergo. It may be remembered that the latter gives rise to the former.

It can further be observed from Table 6 that, not only the magnitude of individual input coefficients change over different age-levels, but also their structure as revealed by the proportion (%) of each coefficient in the total materials-bill varies across the age-levels. That is, the input structure itself undergoes changes over different age-groups or time. To put it differently, the relative importance of each coefficient undergoes changes through time. For instance, "timber" and "explosives" account for 5.5 per cent and 47.7 per cent respectively in the first age-group while these percentages change to 17.4 per cent and 27.3 per cent respectively in the last age group. Percentage composition of material inputs consumption changes over different age-levels firstly due to the changes in the structure of mining operations (Table 5) and secondly due to the changes in the relative position/ importance of each mining process.

Materials consumption structure during different stages of mining operations

Instead of going into the detailed life cycle analysis of materials consumption structure, one can restrict it to the "stages of mining operations". Therefore, what follows is the condensed version of the earlier life cycle trend analysis of annual rate of materials consumption.

The mines that are under study follow the regular "Board and Pillar" method of coal extraction. In this method, there are broadly two stages of mining operations that a coal mine has to adopt during its life span. First is the 'development' stage which is undertaken during the initial period of the mine's life. This stage continues for about 8 to 10 years. During the development stages, tunnels of predetermined size are driven in the coal seam in a criss-cross pattern and, in the process, huge pillars are formed. In this stage, coal extraction takes place only from driving the tunnels. Therefore the percentage recovery of the total embedded

Table 6

The structure and behaviour of materials input consumption in relation to different age-groups (or age of mines)

Sl. No.	Materials class	2—4 years (Mines : A, B, C, D, H, J, O)			5—7 years (Mines : G, F)			8—10 years (Mines : E,R,S,T)		
		Input-Coeff. (Rs./Ton.)	% to total materials input bill	Index	Input-Coeff. (Rs./Ton.)	% to total material input bill	Index	Input-Coeff. (Rs./Ton.)	% to total material input bill	Index
1.	Timber	0.18479	5.5	=100	0.30089	8.4	162 8	0.41061	10.4	222.2
2.	Iron, steel & other metals	0.05940	1.8	=100	0.10152	2.8	170.9	0.09288	2.3	156.4
3.	Pipes & Pipelines fittings	0.06626	2.0	=100	0.03870	1.1	58.4	0.10189	2.6	153.8
4.	Cables (Electrical)	0.05367	1.6	=100	0.00782	0.2	14.6	0.05571	1.4	103.8
5.	Coal drill spares & rails	0.17884	5.3	=100	0.28813	8.1	161.1	0.18109	4.6	101.3
6.	Electrical machinery spares	0.01448	0.4	=100	0.02917	0.8	201.4	0.02217	0.6	153.1
7.	General tools	0.02430	0.7	=100	0.01678	0.5	69.1	0.02044	0.5	84 1
8.	Hardwares	0.03766	1.1	=100	0.04249	1.2	112.8	0.08513	2.1	226.0
9.	Consumable stores (sundries)	0.18354	5.5	=100	0.16050	4.5	87.4	0.19764	5.0	107.7
10.	Electrical goods & accessories	0.05595	1 7	=100	0.03954	1.1	70.7	0.06427	1.6	114.9
11.	Tubs & tub materials	0.27374	8.1	=100	0.30353	8.5	110.0	0.29363	7.4	107.3
12.	Oils, paints and varnishes	0.09062	2.7	=100	0.08853	2 5	97.7	1.11103	2.8	122.5
13.	Explosives	1 60725	47.7	=100	1.58710	44.4	98.7	1.72460	43.5	107.3
14.	Steel wire ropes	0.20620	6.1	=100	0.33344	9.3	161.7	0.27069	6.8	131.2
15.	Stationery	0.03039	0.9	=100	0.02488	0.7	81.9	0.02324	0.6	76.5
16.	Cap lamps & their spares	0.29920	8.9	=100	0.21069	5.9	70.4	0 30715	7.7	102.7
17.	Total Materials input-bill	3.36630	100.0	=100	3.57371	100.0	106.2	3.96217	100 0	117.7
18.	Labour-input coefficient	1.77049	—	=100	1.55407	—	132.8	2.29960	—	19[illegible] 5
19.	Capital input coefficient	0.00604	—	=100	0.00673	—	111.4	0.01472	—	243.7
20.	%of materials bill in pithead costs	27.92	—	=100	24.74	—	88.6	21.68	—	77 7
21.	Electricity	0.91908	—	=100	0.79049	—	86.0	1.32298	—	143 9

Sl. No.	Materials Class	11—13 years (Mines : N, Q)			24 & above (Mines : L, M, P)		
		Input Coeff. (Rs./Ton.)	% to total material input-bill	Index	Input Coeff. (Rs /Ton.)	% to total material input-bill	Index
1.	Timber	0.27757	9.4	150.0	0.42976	17.4	232.6
2.	Iron, steel & other metals	0.06327	2.2	106.5	0.05955	1.6	66.6
3.	Pipes & Pipelines fittings	0.04251	1.4	64.2	0.03261	1.3	49.2
4.	Cables (Electrical)	0.05945	2.0	110.7	0.02010	0.8	37.5
5.	Coal drill/spares & rails	0.11117	3.7	62.2	0.14053	5.7	78.6
6.	Electrical machinery spares	0.01474	0.5	101.8	0.01866	0.8	128.8
7.	General tools	0.01662	0.6	68.4	0.01621	0.7	66.7
8.	Hardwares	0.16841	5.7	447.2	0.03137	1.3	83.3
9.	Consumable stores (sundries)	0.12469	4.2	67.9	0.17057	6.9	92.9
10.	Electrical goods & accessories	0.06692	2.3	119.6	0.05464	2.2	97.6
11.	Tubs & Tub materials	0.23430	8.0	85.6	0.18998	7.7	69.4
12.	Oils, paints & varnishes	0.12658	4.3	139.7	0.10456	4.2	113.4
13.	Explosives	1.11756	30.0	69.3	0.67184	27.3	41.8
14.	Steel wire ropes	0.28262	9 6	137.1	0.32642	13.2	158.3
15.	Stationery	0.02136	0.7	70.3	0 01266	0.3	41.7
16.	Cap lamps & their spares	0.21463	7.3	71.7	0.20342	8.3	68.7
17.	Total materials input-bill	2.94240	100.0	87.4	2.46488	100.0	73.2
18.	Labour input coefficient	1.56044	—	133.3	1.84369	—	157.5
19.	Capital input coefficient	0.00802	—	132.8	0.01127	—	186.4
20.	% of materials bill in pithead COSTS	24 51	—	87.8	16.32	—	58.5
21.	Electricity	1.02657	—	111.7	1.04802	—	114.0

NOTE : These coefficients are found to be abnormal due to the substitution of roof bolts to timber in mine.

NOTE : As machine-mining spares are not consumed in all the mines, they have been deleted in this Table and also in Table 7.

deposit will only be about 20 per cent. The broad economic implications of this stage are as follows : as pillars, will be supporting the roof there will be less timber consumption per tonne of coal raised. The coal face available for blasting will be very small and hence, there will be high per tonne explosives consumption. The yield per blasting will be low due to limited coal face available for extraction and hence, low productivity/ high labour coefficient. As this stage consists of driving tunnels into the seam, the working faces advance into places far off from the pitmouth. In other words, the total haulage distance will continually be lengthened for each additional tonne raised. Longer hauling distance imply less effective labour time, more capital inputs and larger distances amounts of material inputs like steel wire ropes, tubs and tub materials, oils and paints, and so on. This increases the per tonne labour and capital inputs as well as the material inputs required for the general run of the mining operations. Consequently, the unit costs rise, productivity falls and material inputs rise during this stage.

After the development stage, the depillaring stage starts in the coal mining operations. During this stage, the pillars formed in the development stage are extracted totally in a predetermined sequence. The remaining 80 per cent of the mineable coal deposit will be extracted during this stage. This stage continues till the end of the life span of this mine, or in other words, till the deposit is exhausted. The broad economic implications of this stage are as follows. The early part of this stage will be the most productive period during the mine's life span. As pillars will be extracted during this stage, the voids created by coal raisings will be larger and hence, the per tonne timber consumption will be high. The coal face available for blasting is large and hence, low per tonne explosives consumption. Coal yield per blasting is high during this stage and hence, high labour productivity/low labour coefficient. As this stage consists of extracting the pillars from the end point of the coal seam, the working faces start retarding towards the pitmouth and thus, shorten the total hauling distances for each additional tonne so raised. This reduces the per tonne labour and capital inputs as well as the material inputs required for the general run of the mining operations. In other words, the unit costs fall, productivity rises and per tonne material inputs fall during this stage.

There is yet another stage which can be called the 'mixed stage' of mining operations. In the normal course, the depillaring stage will start only after the development stage is completed. However, when there is an undue pressure of coal demand, depillaring will be undertaken simultaneously with the development stage during the last years of the later one. The economic implications of this 'mixed stage' area is a blend of advantages and disadvantages of the two main stages.

The structure and behaviour of material inputs coefficients over different stages of mining operations are given in Table 7. It is evident that there exists a distinct materials consumption structure at each stage. The total per tonne materials-bill or the annual rate of materials consumption declines by about 13 per cent during 'D1 & D2' stage followed by a further decline of 33 per cent during the D2 stage, over the D1 stage. (D1 stage=development stage ; D2 stage =Depillaring stage ; 'D1 and D2' stage=Mixed stage.) Most of the individual material coefficients are found to be lower in D2 stage than in D1 stage, except timber which is higher by about 50 per cent. The per tonne explosives consumption declines sharply by about 59 during the D2 stage over the D1 stage.

Not only the absolute levels of the coefficients, but also the structure (i.e., the percentage composition) of material inputs consumption undergoes changes over stages. Timber forms about 8 per cent of the total materials bill during D1 stage while it accounts for about 18 per cent during D2 stage. Explosives alone contribute 45.5 per cent to the total materials bill during D1 stage, whereas its relative contribution dips down to 28.1 per cent during D2 stage. Similarly, steelwire ropes make a larger relative contribution during D2 stage. Thus, the relative contribution or relative importance of each coefficient in the total materials basket undergoes significant changes over different stages.

The structural changes in the annual rate of materials consumption so far discussed, suggest a policy implication. Some of the shortage of critical or 'A' category materials like 'explosives', 'timber', 'steel-wire ropes', etc., can be met by re-distributing the outputs either over different age-levels or over different stages

of mining operations. If there is a shortage in explosives supply, then the percentage of output from depillaring sections can be increased because of lower per tonne explosives consumption. Thus, the distribution of outputs by age and stages, is a major policy instrument at the corporate level, particularly, during the short run.

Method of estimating the input requirements—A suggested approach

The distinguishing factors of mining operations generate structural (physical) differences among the mines. The result is the large amounts of variability in materials and other inputs consumption. Hence, the predictive value of the material coefficients become 50 low that they cannot yield any reliable estimates or forecasts. However, the study finds that all kinds of structural variations exhibit clearly discernible trends over different age-groups. Age is a catch-all variable in the coal mining industry. It is found that there exists a distinct input structure at each age-level. In view of the life cycle trends both in material coefficients and in other structural differences our study suggests the *age component method*, for estimating the material and other inputs requirements of the coal mining industry. Alternatively, the stagewise projection (or the stage-component method) which is a condensed version of the life cycle trends, can also be used. Instead of estimating the inputs requirements for the aggregate output, it is suggested to get the distribution of the total output by age of mines or stages of mining operations and then apply the age-wise (or stage-wise) input coefficients to the age-wise (or stage-wise) outputs, to get the total input requirements. This method is likely to give more reliable estimates or forecasts because most of the inter-mine variations are taken care of. The forecasts by either method will be equally reliable. According to this approach, materials planning needs as a prerequisite, the planning of age-composition or stage-composition of outputs. When once the planning for outputs is done, material forecasts can be prepared by using the life-cycle coefficients.

Table 7

The Structure and Behaviour of Materials Input Coefficients Over Different Stages of Mining Operations

Sl. No.	Materials-class	D1 Stage		D1 & D2 Stage		D2 Stage	
		Input-coeff. (Rs./Tonne)	%	Input-coeff. (Rs. Tonne)	%	Input-coeff. (Rs./Tonne)	%
1.	Timber	0.28466	8.02	0.41930	13.55	0.42976	17.97
2.	Iron, Steel & Other metals	0.08027	2.26	0.06630	2.14	0.03935	1.65
3.	Pipes & Pipelines fittings	0.07284	2.05	0.04756	1.54	0.03261	1.36
4.	Cables (Electrical)	0.03490	0.98	0.05945	1.92	0.02010	0.84
5.	Coal drill spares & rails	0.20964	5.91	0.12126	3.92	0.14053	5.88
6.	Electrical Machinery spares	0.02109	0.59	0.01467	0.47	0.01866	0.78
7.	General tools	0.02037	0.57	0.01775	0.57	0.01621	0.68
8.	Hardwares	0.04720	1.33	0.03890	1.26	0.03137	1.31
9.	Consumable Stores (sundries)	0.19193	5.41	0.16906	5.49	0.17057	7.13
10.	Electrical goods & accessories	0.05334	1.50	0.06732	2.17	0.05464	2.28
11.	Tubs & tub materials	0.27894	7.86	0.25015	8.08	0.18988	7.94
12.	Oils, paints & Varnishes	0.10380	2.92	0.11942	3.86	0.10456	4.37
13.	Explosives	1.61597	43.53	1.15199	37.23	0.67184	28.09
14.	Steel wire ropes	0.25118	7.08	0.28469	9.20	0.25342	10.59
15.	Stationery	0.02810	0.80	0.02040	0.66	0.01266	0.53
16.	Caplamps & their spares	0.25494	7.18	0.24563	7.94	0.20542	8.59
17.	Total Material Input-bill	3.54919	100.00	3.09465	100.00	2.39188	100.00
18.	Labour input coefficient	1.72723		1.56043		1.84369	
19.	Capital input coefficient	0.00854		0.00919		0.01126	

NOTE : D1 Development Stage D1 & D2 : Mixed stage
D2 Depillaring Stage

SECTION IV

A demonstration exercise is presented using the methodology suggested earlier. The exercise is made on the estimation of materials requirements for the sixth plan coal targets. The sixth plan envisages an annual coal target of about 150 million tonnes. The coal industry has to rely much on the supplying factors for various material needs to achieve its targets. The exercise indicates the amounts of various kinds of materials required per annum to produce the targeted level of output. It assumes that the relative price structures as well as the relative changes in prices and wages are same between the current period and the survey period. It may be noted that the age-component method has been suggested for the underground output or mining only. In the present exercise, it is assumed for all the scenarios that the underground output forms 75 per cent of the total output during the sixth plan period. In other words, the exercise refers to 112.5 million tonnes of India's underground coal output target.

The forecast by age-component method are made under the following four scenarios;

Scenario I : Total average cost is Rs. 71 per tonne. All industry aggregate coefficients.

Scenario II : Total average cost is Rs. 71 per tonne. Age-composition of output biased towards new mines.

Scenario III : Total average cost is Rs. 73 per tonne. Age-composition of output biased towards middle and/old aged mines.

Scenario IV : Total average cost is Rs. 75 per tonne. Age-composition of output is as found in our survey.

The forecasts under the stage-component method is made under one broad Scenario ; Scenario I : Total average cost is Rs. 71 per tonne. Stage composition of output as given in the text.

The method of estimation is as follows. As a first step, we have obtained the materials cost per tonne for the all-India coal industry by using the cost structure (between wages & materials) as found out in our survey. The per tonne materials cost for each age-group has been obtained by multiplying the aggregate materials cost/tonne with the following factors :

Age group	*Factors*
2-4 years	1.0435
5-7 Years	1.1078
8-10 Years	1.2282
11-13 Years	0.9121
24 & above	0.7641

These factors are nothing but the differentials obtained by dividing the age-group-wise per tonne total materials bill with the all-industry (aggregated over 18 mines) bill They refer to and are based upon our survey data. By using the above multiples, 'age-group' wise per tonne materials-bill is obtained. After getting this, the age-wise percentage of material coefficients (as found in our survey-Table 6), are applied to get the total class-wise material requirements. All these age-wise requirements are aggregated across the age-groups to get the total all-India coal industry's materials requirements. A similar method of estimation is used for the stage-component method.

Assumed age-composition of outputs for the Sixth-Plan annual coal targets of 112.5 million tonnes of underground output, is given in Table 8. This is given for each scenario. The assumed age-compositions of output (as given in Table 8) imply various alternate policy options of the coal sector in regard to expansion by way of opening up of new coal fields/mines. In regard to the stage-composition of Sixth Plan annual coal targets, the following is assumed :

Development Stage : 40% = 45 million tonnes

Mixed Stage : 20% = 22.5 million tonnes

Depillaring Stage : 40% = 45 million tonnes

This has been assumed on the basis of our past knowledge regarding the trends in the stage-composition of outputs in the India's coal mining industry. For the above stage-composition of output, the stage-wise structure of materials coefficients (as found in our survey-Table 7) has

Table 8

Assumed Age Composition of Outputs Under Different Scenarios for the Sixth Plan Annual Coal Output Target of 112.5 Million Tonnes

Sl. No.	Age-group	In our Survey	Age-composition of output under		
			Scenario II	Scenario III	Scenario IV
1.	1-4	22.03	23.00 (28.125)	10.00 (11.250)	22.00 (24.750)
2.	5-7	10.05	15.00 (16.875)	15.00 (16.875)	10.00 (11.250)
3.	8-10	15.56	20.00 (22.500)	15.00 (16.875)	16.00 (18.000)
4.	11-13	19.90	20.00 (22.500)	20.00 (22.500)	20.00 (22.500)
5.	24 & above	32.46*	20.00 (22.500)	40.00 (45.000)	32.00 (36.000)

* The output raised from the age-group of 17-19 years has been added to this age-group, because the input structure for that age-group could not be obtained.

NOTE : Figures in brackets show the absolute levels of output in million tonnes. Total output is 112.5 million tonnes.

been applied to get the total class-wise material requirements under the stage-component method. Aggregation is made across the stages.

The estimates of materials requirements for the Sixth Plan coal targets as presented in our exercises (See Tables 9, 10 and 11) are restricted only to those that are needed to get the coal raisings from the underground workings to the pitmouth. They refer to pithead (underground + surface) costs only. They do not, therefore, cover those materials that are consumed in the Central Workshops for major repairs. They also do not, cover those that are consumed in coal screening plants. Similarly, the materials that are consumed on the maintenance of overhead infrastructures are not covered by our exercises because they are independent of the age-component method. As they are guided by and adhere to non-production factors, they are to be estimated differently. However, we have not attempted this exercise.

The results of our exercises clearly indicate that the annual rate of materials consumption (or requirements) is very sensitive to the changes in the age composition (as also the stage composition) of the annual rate of output. The age-composition is amenable to deliberate changes. Therefore, the age-composition of outputs becomes a short-term policy instrument with which one can meet some of the problem of materials supplies. The exercise also indicates some broad guidelines for the supplying sectors to plan their production capacities.

Thus, this would also avoid the bottlenecks in the supplies to the coal sector. The results of the exercise can also be used as a feedback to the coal sector for planning their outputs depending upon the extent of materials availability in the economy. They can also be used in matters relating to the substitution of materials, e.g. timber with metals or vice versa, metal pipes with hose (rubber) or cotton pipes and so on.

The results of our exercise (See Tables 9, 10 and 11) are both indicative and demonstrative. The study suffers from one major limitation. That is, the age-distribution of surveyed mines is not very even, particularly during the later part of the mine's life span. However, the approach remains valid. Another limitation is that the results include the impact of various geological factors as found in our surveyed mines. Regarding mechanisation, we have estimated separately under "machine-mining spares" which comprises all the sophisticated spares. Age-component method could not be applied in this case because all the mines are not consuming these materials. In the surveyed

Table 9

SCENARIO I : Annual Materials Requirements for the Sixth Plan annual coal output target of 12.5 million tonnes, by applying the All-Industry aggregate coefficients.

Sl. No.	Materials Class	Total inputs (Rs. million)
1.	Timber	93.61
2.	Iron, Steel & other metals	19.63
3.	Pipes & pipeline fittings	16.50
4.	Cables	12.42
5.	Coal drill spares & rails	49.22
6.	Electrical machinery spares	5.41
7.	General tools	5.41
8.	Hardwares	22.38
9.	Consumable stores	49.03
10.	Electrical goods & accessories	16.98
11.	Tubs & tub materials	73.40
12.	Oils, paints and varnishes	32.91
13.	Explosives	370.23
14.	Steel wire ropes	81.84
15.	Stationery	6.54
16.	Machine mining spares	19.54
17.	Cap lamps and their spares	73.21
18.	Total material-bill (mil. Rs.)	948.375
19.	Total materials bill per Tonne (Rs.)	8.43

TAC=Rs. 71 per tonne
Production cost=71×0.60=42.60 per tonne.
Pithead cost=42.6×0.86=36.64 per tonne.
Materials cost=36.64×0.23=8.43 per tonne.

industry, there is a mine which is partially (about 30%) mechanised. This is the basis on which the estimate has been made. Though it can have an indicative value, it may not be a reliable one.

Coal industry can, by adopting the age-component of stage-component (or both) method, prepare more reliable estimates of materials requirement. All kinds of structures, as are necessary in the analysis of materials planning, will be valid and stable for fairly long periods of time. They change only when there are major technological changes in the industry or when there is a major shift in the methods of mining. They also change when there are major relative price or wage changes or any other basic change in the economy. When there are such changes, the structures can be up dated. When once the structures and the age-wise coefficients are prepared, they can be stored and used for fairly long periods of time.

By and large, materials policy and planning depends upon the corporate policy regarding the conservational problems, output planning in sense of age-composition, expansion policy regarding opening up of new fields/mines, mechanisation, methods of mining etc. As the material requirements (as also its composition) are sensitive to changes in the age (or stage) composition of outputs, it is suggested that there should be a clearly defined output planning on the basis of which alone a reliable materials planning can be prepared.

Table 10

Annual materials requirements for The Sixth Plan Annual Coal Target of 112.5 million tonnes. By applying the age-component method

Sl. No.	Materials Class	Scenario II (Rs. Mil.)	Scenario III (Rs. Mil.)	Scenario IV (Rs. Mil.)
1.	Timber	92.54	106.39	102.72
2.	Iron, steel & other metals	24.82	19.17	19.72
3.	Pipes & pipelines fittings	17.03	14.84	16.78
4.	Cables	12.16	10.40	12.26
5.	Coal drill spares & rails	51.21	50.32	50.95
6.	Electrical machinery spares	5.68	6.05	5.86
7.	General tools	5.73	5.58	5.95
8.	Hardwares	21.24	20.83	21.88
9.	Consumable stores	49.61	49.88	52.04
10.	Electrical goods & accessories	16.84	17.32	17.87
11.	Tubs & tub materials	75.68	72.45	76.17
12.	Oils, paints & varnishes	30 67	31.98	32.73
13.	Explosives	394.65	347.55	380.77
14.	Steel wire ropes.	81.54	89.84	87.68
15.	Stationery	6.66	5.86	6.53
16.	Caplamps & their spares	73.92	70.15	75.81
17.	Total materials bill (Rs. Mil.)	960.03	948.61	965.20
18.	Total materials bill per tonne (Rs.)	8.43	8.66	8.90
19.	Machine mining spares	19.78	18.92	19.88
20.	Total materials bill (Rs. Mil.)	979.81	957.53	985.08

NOTE : Machine-mining spares are not consumed in all the mines. Therefore, age-mine coefficients are not computed. Instead, the all Industry proportion of 2.06% is used to estimate its requirements under all the scenarios.
Assumptions : Scenario II : TAC=Rs. 71 per tonne : Production cost=71×0.6=42.6/tonne pithead cost=42.6×0.86 =36.64 Rs./tonne· Materials Cost=35.64×0.23=8.43 Rs./Tonne.
Scenario III : TAC=Rs. 73 per tonne ; Production cost=73×0.60=43.80 per tonne Pithead cost=43 8×0.86=37.6 Rs./Tonne; Materials Cost=37.67×0.23=8.66 Rs./Tonne.
Scenario IV : TAC=Rs. 75/Tonne; Production cost=75×0.60=45 Rs./Tonne; Pithead cost=45×0.86=38.70 Rs /Tonne; Materials cost=38.70×0.23=8.90 Rs./Tonne.

Table 11

Annual materials requirements for the Sixth Plan Annual Coal Targets of 112.5 million tonnes, by applying the stage–component method

Sl. No.	Materials Class	Total (Rs./Million)
1.	Timber	108.67
2.	Iron, steel & other metals	17.97
3.	Pipes & pipeline fittings	15.18
4.	Cables	9.94
5.	Coal drill spares & rails	48.33
6.	Electrical machinery spares	5.51
7.	General tools	5.33
8.	Hardwares	11.62
9.	Consumable stores	52.61
10.	Electrical goods & accessories	16.62
11.	Tubs & tub materials	69.83
12.	Oils, paints & varnishes	31.50
13.	Explosives	336.70
14.	Steel wire ropes	76.06
15.	Stationery	6.03
16.	Cap lamps & their spares	68.56
17.	Total materials bill (Rs. Mil.)	880.43
18.	Total materials bill per tonne (Rs.)	8.43
19.	Machines mining spares	18.14
20.	Total materials bill (Rs. Mil.)	898.57

NOTE : TAC=Rs. 71 per tonne ;
Production cost=71×0.60=Rs. 42.6 per tonne.
Pithead cost=42.6×0.86=Rs. 36.64 per tonne.
Materials cost=35.64×0.23=Rs. 8.43 per tonne.

REFERENCES

1. *Monthly Statistics of the Production of Selected Industries of India*, July & Aug. 1967 (Supplement), page 82 Central Statistical Organisation (Industrial Statistics Wing), Department of Statistics, Cabinet Secretariat, Government of India, Calcutta.

2. For a detailed disaggregative process-wise cost analysis and the classification of costs in the coal mining industry, see author's unpublished Ph.D. thesis, "Economic analysis of the coal mining industry with some Empirical Explorations with behaviour of costs and input-output relations", submitted to the University of Poona. Henceforth, this will be referred to as *the thesis*.

3. A regression model fitted for 21 coal mines with the number of working faces in a mine as independent variable (X) and the mine-output ('00 tonnes) as dependent variable (Y), gives the following equation :

$$Y = -32.599 + 20.509X \qquad R^2 = 0.92$$
$$(15.43)$$

Figure in bracket shows the t-value. The regression coefficient is significant at 1 per cent level.

4. A regression model fitted for 20 mines with the age (in years) of mines as independent variable (X) and the output size (in '00 tonnes) of mines as dependent variable (Y) gives the following equation :

$$Y = 39.325 + 345.710X - 9.516X^2 \qquad (R^2 = 0.60)$$
$$(4.28) \qquad (-3.13)$$

Figures in brackets show t-values. The regression coefficients are significant at 1 per cent level which confirms an inverted U shaped relation between Y and X. This would suggest that the very new and the very old mines have lower rates of extraction. The later case is due to the depletion effect and the former is due to lack of physical extraction facilities on the one hand and due to lack of availability of adequate number of working faces on the other. This age-size relationship is ingrained in the nature of mining operations. In view of this relationship, one can also regard the structural changes that a mine undergoes through age/time as those through the cumulated output levels.

5. See Ch. VI of *the thesis* which deals exclusively with the life cycle theory of the coal mining indnstry. A similar N-shaped relationship is found between the age of a mine and the average operating/production costs.

6. The input structure in the case of open cost mining will be entirely different from that of the underground mining. The determining factors are also different. Therefore, it needs a sep arate methodology which lies outside the scope of our study.

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Capacity Utilization in Public Sector Steel Plants

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The under-utilization of capacity in the three integrated public sector steel plants has been due to a large variety of factors..... There should now be a drive towards optimal utilization of capacity through increased productivity, modernisation and technological improvements.

"Unfortunately, Public Corporation and Government Companies often tend to assume the role of prodigal sons and daughters and, as the family grows, this role becomes increasingly unbearable."[1] Similarly, the cost of production in public sector steel plants—Bhilai, Durgapur and Rourkela, is unbearable with the expansion of public sector in Indian economy. The loss in steel, coal and aluminium were particularly deplorable since they accounted for nearly 40 per cent of the investment. The loss in these plants was anticipated for first four or five years. But at least after the initial gestation period they should start earning profit and try to wipe out the losses. But this was not happening in the public sector of India due to low rate of capacity utilisation which is the result of low labour productivity, non-availability of high quality raw materials, bad industrial relations and certain other administrative and technical factors. In the present paper the problems in the way of capacity utilisation in public sector steel plant (Bhilai, Durgapur and Rourkela) in the light of these factors, has been brought out.

In 1911 India's first Iron and Steel Plant, The Tata Iron and Steel Company Limited (TISCO) was set up in Jamsedpur in Bihar in the private sector. Nearly three and a half decades later another plant was launched in Burnpur—the Indian Iron and Steel Company (IISCO) also in the private sector (now in public sector). These two plants were all India inherited in this very vital field at the time of independence. The Industrial Policy Resolution of 1948 accepted the crucial importance of the steel industry and decided that integrated

steel plants built in the future should be placed in public sector. About a decade later, three new integrated plants were set up at Rourkela, Bhilai and Durgapur. The fourth integrated steel plant in the public sector at Bokaro was built for a production capacity of 1.7 million metric tonnes. The production capacity of the three plants was subsequently raised from one million metric tonnes each to 2.5 million tonnes at Bhilai, 1.8 metric tonnes at Rourkela and 1.6 million metric tonnes at Durgapur. In 1973, the Government wedded the integrated plants together until then managed by the Hindustan Steel Limited (Bhilai, Rourkela and Durgapur) and set up the Steel Authority of India Limited (SAIL) as a holding company. The six integrated steel plants have a total production of 10.6 million metric tonnes.

The Rourkela Steel Plant is designed to produce flat products such as plates, sheets, strips and tin plates and also larger diameter pipe. The main by-products of Rourkela Steel Plant are benzol, tar and ammonium sulphate.

The Durgapur Steel Plant has six finishing mills—section mill, merchant mill, skelp mill, wheel and axle plant, fish plate plant and sleeper plant. Durgapur produces special items for the railway, wheel and axle sets, sleeper bars, fish plates etc. It also produces skelp, light structurals and other construction materials such as billets, etc. The main concern of the plant is to produce ingot of steel and to convert them into saleable steel. In this process of production and conversion, various by-products such as tar products, ammonium sulphate and benzol products are received. The main products of Bhilai Steel Plant comprise rails, sleeper bars and crossing sleeper, heavy structurals, angles, rounds and squares, billets and foundry-grade pig iron.

TREND OF CAPACITY UTILISATION

It will be seen from Table-I and II that there were wide range of differences as well as fluctuation in capacity utilisation not only with regard to one plant to another but one product to another as well. The capacity utilisation were

Table I

Capacity Utilisation - Main Products

(Unit in %)

Year	STEEL INGOTS			PIG IRON FOR SALE			SALEABLE STEEL		
	BSP	DSP	RSP	BSP	DSP	RSP	BSP	DSP	RSP
1967-68	72	74	52	61	93	85	64	66	52
1968-69	70	82	63	72	115	196	68	63	63
1969-70	74	51	61	65	123	177	76	40	64
1970-71	78	40	58	72	110	126	78	33	56
1971-72	78	44	48	62	90	170	80	55	49
1972-73	84	45	65	60	33	95	88	30	62
1973-74	76	48	60	56	42	61	86	38	60
1974-75	80	51	59	59	42	154	86	42	66
1975-76	88	62	71	61	45	155	94	61	85
1976-77	92	68	84	94	68	85	103	73	96
1977-78	84	74	85	78	33	22	96	76	95

Source: Various Annual Reports of HSL and SAIL (Table Compiled)

Table II

Capacity Utilisation-By-Products

(Unit in %)

Year	TAR PRODUCTS			BENZOL PRODUCTS			AMMONIUM SULPHATE		
	BSP	DSP	RSP	BSP	DSP	RSP	BSP	DSP	RSP
1967-68	82	58	80	54	37	38	58	76	27
1968-69	80	74	82	60	75	53	74	66	54
1969-70	85	74	74	54	83	31	80	71	45
1970-71	85	74	66	44	77	30	77	62	30
1971-72	74	54	59	48	60	7	63	57	26
1972-73	94	—	66	33	—	18	77	—	42
1973-74	—	70	56	46	62	22	72	57	42
1974-75	81	69	64	50	38	17	80	44	46
1975-76	92	72	78	70	17	45	86	47	54
1976-77	102	58	90	81	24	58	100	57	62
1977-78	102	—	81	87	—	47	105	55	63

Source : Various Annual Reports of HSL and SAIL (Table Compiled)

71 per cent, 73 per cent and 53 per cent respectively in Bhilai, Durgapur and Rourkela with regard to steel ingots. In 1970-71, while capacity utilisation in Bhilai and Rourkela increased by 84 per cent and 65 per cent respectively in 1971-72 it had declined by 45 per cent in Durgapur. The level of capacity utilisation with regard to steel ingots was far better in the case of Bhilai and Rourkela in comparison to Durgapur in 1977-78. While the level of capacity utilisation with regard to pig iron for sale had improved in Bhilai in 1977-78 in comparison to 1967-68, it was worst in the case of Durgapur and Rourkela. The level of capacity utilisation with regard to saleable steel has improved in all the three integrated steel plants as shown in the Table-I.

The main concern of Bhilai, Durgapur and Rourkela is to produce ingots of steel and to convert them into saleable steel. In this process of production and conversion, various by-products such as tar product, benzol product and ammonium sulphate are received at the by-products plant. The under-utilisation of capacity, existed in the area of by-products also. The production of by-products, ammonium sulphate and benzol products was considerably lower than capacity in many years of the present study as has been shown in Table-II and like ingot steel and saleable steel, the production of these by-products in 1977-78 was lower as compared to that in 1967-68.

REASONS FOR THE UNDER UTILISATION

The fundamental factors influencing 'the low capacity utilisation in public sector according to studies conducted by Raghunath K. Koti[2] are lack of demand and shortage of raw material and components. In the view of Professor Samuel Paul,[3] explanation for the under-utilisation of industrial capacities in the Indian Economy could be sought in phenomena such as market structure, pressure of demand, size of the firm,

import substitution, effective rate of protection, raw materials allocation, major additions of capacity in the preceding year, strikes, power shortage and transport bottlenecks. The under-utilisation of capacity in three integrated public sector steel plant viz. Bhilai, Durgapur and Rourkela has been the mix of a large variety of factors. The present study brought out the following reasons responsible for this underutilization :

1. Indifferent Industrial relations.
2. Low labour productivity.
3. Poor and deteriorating quality of coal.
4. Inadequate availability of power.
5. Shortage of refractories.
6. Lack of proper maintenance.

These factors are elaborated below :

1. Industrial Relations

Industrial relations in public sector steel plants were uneasy during 1977-78 and have adversely affected capacity utilisation. The Bhilai Steel Plant has now caught the nation's attention for bad industrial relations.[4] Trade unions help is now being sought by the Ministry of Mines & Steel to boost steel output. Several causes are responsible for bad industrial relations in these steel plants. The main cause for labour unrest is inter-union and intra-union rivalry. There are 7 unions in Durgapur Steel Plant, 6 in Rourkela Steel Plant and 8 in Bhilai Steel Plant. It is obvious that in a situation where conflicting ideologies and leadership are operating, industrial peace will be hard to maintain. Even where unions are recognised and have a fairly large following, group and factions have developed because of ideological and personality conflicts. Consequently, management has not always been able to get cooperation even from these recognised trade unions.

The employees of public sector steel plants were on the war path after March, 1977.[5] The employees raised various demands relating mainly to upgradation of posts and revision of incentive scheme etc. and resorted to various forms of agitation to press their demands.

Table III

Manhours and Value of Production Loss

(Unit in Crores)

Year	BHILAI		DURGAPUR		ROURKELA	
	Manhours	Production	Manhours	Production	Manhours	Production
1967-68	0.08	0.72	0.10	10.97	0.002	6.33
1968-69	0.01	0.06	0.05	19.06	Nil	Nil
1969-70	0.31	4.48	0.05	11.63	0.16	7.09
1970-71	Nil	Nil	0.17	11.15	0.29	12.04
1971-72	0.0002	0.047	0.86	8.06	0.0003	0.03
1972-73	0.0005	0.006	0.26	4.95	0.002	3.92
1973-74	0.004	0.130	0.18	5.91	0.005	7.89
1974-75 (April-July)	0.00006	0.028	0.0001	0.163	0.0004	0.359
1977-78	0.03	0.002	0.01	0.0003	0.13	0.005

Source : Annual Report on the working of Industrial and Commercial undertaking.

Approximately 13,600 man days were lost in four steel plants during 1977-78 in comparison to no loss in man hours due to industrial relations problem in any of the steel plants (except Alloy Steel Plant, which lost 296 manhours) during 1976-77[6]. These labour problems were the main obstaclesin the way of full use of capacity.

2. Labour Productivity

Productivity is a statistical concept expressed as a ratio between output and input. The yardstick for measuring labour productivity for Indian Steel Plants is expressed in terms of "Ingot tonnes per man-year". In calculating this, the production of ingot steel and 25 per cent of pig iron for sale and the manpower employed (direct and indirect) for the production of the same are taken into account. It will be seen from Table-IV that labour productivity is very low in the public sector steel plants of India. Labour productivity in Bhilai, Durgapur and Rourkela during 1968-69 was 75, 48 and 59 respectively. These figures increased slightly to 87, 49 and 56 in Bhilai, Durgapur and Rourkela respectively in 1977-78. Labour productivity in these steel plants has been influenced by overstaffing, lack of major capital repair and availability of bad quality of raw materials.

Table IV

Average Labour Productivity in tonnes

Year	PLANT		
	Bhilai	Durgapur	Rourkela
1968-69	75	48	59
1969-70	79	54	54
1970-71	70	32	35
1972-73	72	31	50
1973-74	63	33	42
1975-76	76	44	55
1976-77	82	49	56
1977-78	87	49	56

Source : Report of C.P.U. on SAIL—1975-76 and 1977-78

Table V

Supply of Coal to Steel Plants

(Unit in million ton)

Year	Demand	Supply	Short fall
1972-73	14.18	11.42	2.76
1973-74	14.74	11.30	3.44
1974-75	13.36	11.45	1.91
1976-77	14 66	14.11	0.55
1977-78	15.96	14.92	1.04
1978-79 (April-October)	9.47	8.05	1.42

Source : 30th Report of Sixth Lok Sabha of C.P.U. on SAIL—1978-79.

3. Poor and Deteriorating Quality of Coal

The perennial problems of inadequate supplies and poor quality of coking coal and power had proved stumbling blocks in the realisation of steel production targets. The coal pushings have been precariously low during the past few years resulting in huge loss in production. The coal authorities had agreed in the beginning of the year to supply 46,000 tonnes of coking coal to the steel plants for their daily requirements. But the actual supplies have been less than 40,000 tonnes during the first three months of 1979.[7] Apart from availability, the steel industry has to use coal with dust content of 25 to 28 per cent against the safe limit of 16 per cent. The quality of the coal blend that is charged in the oven at Durgapur Steel Plant depends upon the quality of incoming coal both as washery feed as well as direct feed coal. In both the cases, there has been a gradual deterioration in quality because of deeper mining.

As an example, while the ash content of the coal blend foreseen in the project report was to vary between 16 and 17 per cent, the actual ash content for the period 1969-70 to 1977-78 can be seen from Table VI. It can be seen from the Table that the ash content is high. Every one per cent increase above the desired level means a loss of 2.5 per cent in steel production.

Table VI

Ash Content in Blend Coal at Steel Plant

(Unit in %)

Year	Bhilai	Durgapur	Rourkela
1973-74	17.96	20.52	18.23
1974-75	18.09	21.25	18.68
1975-76	18.86	21.12	19.11
1976-77	18.97	20.22	18.98
1977-78	19.84	20.44	19.05
1978-79 (April-September)	19.93	20.03	18.92

Source : Report of the C.P.U. on SAIL—1978-79

4. Shortage of power

Steel plants in the recent past have also suffered loss of production in varying degree on account of constraints in power availability. In fact, shortage of power could be described as one single reason responsible for the low utilisation of capacities during 1970-71 to 1974-75. The position regarding power availability from DVC system to steel plant at Durgapur became very critical from April, 1979 onward. Apart from the fact that the power supply was less than the minimum needed there have been frequent fluctuations. Voltage fluctuations at times caused damage to many sensitive equipment of the steel plants. The production of saleable steel has been seriously affected due to acute shortage of power in recent years.

5. Shortage of Refractories

Refractories have also been in short supply. The supply of finished refractories to the steel plants has slowed down to a trickle because there are not enough railway wagons. The refractory units are also facing the problem of getting adequate raw materials. The problem has been accentuated by the railway's insistence that refractories be moved in rakeloads. While this may be feasible for the movement of bulk commodities, finished refractories could not be transported in rakeloads.

6. Lack of Proper Maintenance

Sustained attention has not been paid towards repair and maintenance of the plants and machinery especially in Durgapur Steel Plant resulting in a large number of breakdowns. Proper maintenance of plant and machinery is a must to ensure trouble-free operation of the plants at maximum efficiency. The three integrated steel plant have got separate maintenance department independent of the production departments. It is, however, noticed that there have been a large number of major breakdowns (over 8 hours) in all the three steel plants. The sample detail of such breakdowns during the last three years is given in Table-VII.

The large number of breakdowns especially in Durgapur Steel Plant shows that due attention has not been paid to regular preventive maintenance of the plant and machinery.

Table VII

Hours lost due to lack of Maintenance

Plant	1967-68	1968-69	1969-70
Bhilai	396.3	181.7	328.70
Durgapur	3543.3	5464.3	5054.8
Rourkela	315.2	418.2	880.5

Source : 77th Report of Fifth Lok Sabha of C.P.U. on SAIL—1975-76

Impacts of Low Level of Capacity Utilisation

The low level of capacity utilisation in any industrial unit adversely affects three factors; cost of production, price and profitability. The cost of under utilisation of rated capacities in steel is rather heavy which perhaps a country like India cannot afford. For the purpose of this study four aspects viz. cost, price, profitability and exports have been taken. In the subsequent paragraphs all these aspects have been explained in detail.

Table VIII

Actual cost as percentage of project report estimates

Plant	1965-66	1966-67	1967-68	1968-69	1969-70
Bhilai	127	129	142	151	166
Durgapur	145	161	193	203	197
Rourkela					
(a) Open hearth process	179	191	220	216	264
(b) L. D. Process	191	212	250	251	259

Source : Report of C.P.U. on Hindustan Steel Limited, 1971-72

1. Cost of Production

Table VIII shows the actual cost of production of ingot steel for the three plants (work cost excluding depreciation and interest) during the last five years expressed as a percentage of project estimates. It will be seen from the Table that the actual cost of production has been much higher than the project report estimates. There has also been substantial increase in the cost of production since 1965-66. Extent of increase per tonne was Rs. 45.24 for productive material (50%), Rs. 34.38 for operating cost (38%), Rs. 10.78 for overhead (12%), Rs. 90.40 for work cost (100%).

2. Profitability

The Hindustan Steel Limited for the first time showed a profit of Rs. 4.71 crores in 1971-72 and Rs. 27.80 crores during 1972-73 respectively. During 1974-75 the Hindustan Steel Limited made a profit of Rs. 48.24 crores compared to the profit of Rs. 4.71 crores during 1973-74. Steel plants under SAIL made an all-time record profit of Rs. 69.22 crores in 1976-77, when the level of capacity utilisation in the integrated public sector steel plants were highest during the decade, as against Rs. 27.22 crores in 1975-76. See Table IX. The profitability of the plant had been adversely affected by the low level of capacity utilisation.

3. Pricing

The pricing policy of public enterprises assumes considerable significance in the context of utilisation of capacity. Based on the low level of capacity utilisation in the three integrated public sector steel plants in 1972-73, prices of all categories were uniformly raised by Rs. 75 a tonne in 1973. The capacity utilisation in 1977-78 was 83 per cent and the steel price has increased by Rs. 175 per tonne in May 1978 and further in April 1979 by Rs. 100 per tonne.

Table IX

Relationship of utilised capacity & profit

Year	Average level of capacity utilised in three Integrated plants	Profits (+) Loss (−) Rs. in lakhs
1968-69	69	(−) 3991.66
1969-70	62	(−) 1047.28
1970-71	58	(−) 540.61
1971-72	56	(−) 4484.58
1972-73	64	(−) 2779.69
1973-74	64	(+) 471.25
1974-75	65	(+) 4824.30
1975-76	74	(+) 4466.11
1976-77	85	(+) 6746.14
1977-78	83	(+) 4678.26

Source : Annual Report of SAIL and HSL for various years

4. Export

With the drop in production and capacity utilisation of the steel plants, the imports of steel in the first five months of 1978-79 have already far exceeded the total imports in 1977-78. From being an exporter of steel in the previous two years India had to heavily depend on imports with no exports at all in this year. Even the imports that are channelised through the SAIL in these five months of 1978-79 are over 5 lakh tonnes, while together the channelised and non-channelised imports of steel in 1977-78 amounted to 4.94 lakh tonnes. The exports in 1977-78 amounted to a huge figure of 18.51 lakh tonnes. In 1978-79 exports stood at 9.43 lakh tonnes, against imports of only about 4.94 lakh tonnes. In view of the internal shortage the Government had banned the exports of steel items. The drop in production was due to the low capacity utilisation of the public sector steel plants.

5. Future Prospects

The major expansion of existing steel plants, during the sixth plan, is designed to raise the capacity of all the three integrated public sector steel plants. Bhilai Steel Plant is estimated to raise its capacity to four million tonnes per annum before the end of the plan. Modernisation and replacement programmes aimed at optimum utilisation of capacity are being put through at Durisapur and Rourkela. Technological improvemengs such as reduction in the norms consumption t of coking coal, improvement of LD lining life, production of value-added steels and general improvements in blast furnance, sintering, steel making and rolling technology are being introduced into practically all the steel plants. To cope with the planned increase in steel output, captive facilities in mines, refractories and power production are being expanded. For example, in order to insulate the steel plants from the vagaries of power supply of the public distribution system, as many as seven 60 MW thermal generating sets would be installed in the steel plants during the VIth plan.

In Bhilai, apart from stepping up the crude output from the existing level of 2.5 million tonnes to four million tonnes per annum, a second sinetering plant and a new refractory plant are being established. The sinetering plant was to be commissioned in 1978 while the refractory plant would be in production by mid 1980. The capacity utilisation at the Durgapur Steel Plant is sub-optimal for a variety of reasons. It is proposed during the plan to bring up its level of capacity utilisation and to restore its technical and financial health through a series of rehabilitation and diversification programmes. In Rourkela, the 1700 mm semi-continuous hot strip mill, installed in 1961, requires revamping to bring it in line with modern technology. The hot strip mill is being modernised during the plan. A major feature in the coming year is the establishment, for the first time in the country, of facilities for production of 37,500 tonnes of cold-rolled, grain oriented and 36,000 tonnes of cold-rolled, non-grain-oriented electrical steel sheets required by the power equipment industry in the country and currently totally met by import. The cold rolled electrical steel sheets to be produced by the plant would incorporate the latest technology to permit highly efficient and economical designs of transformers.

Raw material supplies and other connected infrastructure facilities may turn out to be major bottlenecks in achieving the long term steel target fixed at 18 million tonnes for 1985 and 24 milllon tonnes for 1988-89. This calls for a massive effort from input industries like coking coal, power, transportation and ferro alloys. For example coking coal requirements would go up from 16.42 to 19.7 million tonnes. Non-coking coal requirements would have to be set up from 3.3 to 4.63 million tonnes. What causes real concern to the steel plant management in the coming years is the growing need for power. From 5435 mega units, a higher steel target of 13 million tonnes would involve a power requirement of 6673 mega units.

A scrutiny of the record of supplies by the input industries like coal, power and rail transport makes dismal reading. Not only did they fail to keep to the targets assigned to them after long and protracted deliberations, they nearly wrecked the steel plants. Transport will create more difficulties in coming years. In the past two years and more there has been a tussle among steel plant management, coal authorities and the railways as to who should share the blame for the total failure of movement of coal to steel plants and other consumers. If it is continued in the coming years the steel plants

may face a real crisis.

The investible national financial resources being limited, it is only prudent and proper that in the areas of highly intensive industries like steel, the emphasis on planning for growth should shift from new greenfield plants to expansion of existing production facilities together with a drive towards optimal utilisation of capacity through increased productivity, modernisation, diversification and technological improvements. The engineering industries in the country could play a major role in advancing towards new frontiers in steel production and technology in the coming years.

REFERENCES

1. Om Prakash *The Economic sins of Nation (A Monologue on Economic Discipline)* Progressive Publishers: Calcutta, 1978 Page 283.
2. Ragunath K. Koti, *Capacity Utilization and Factor Affecting it in certain Industries, 1966-67* Mimegraphy No. 2 Poona, Gokhale Institute of Economics and Policies, 1967.
3. Planning Commission (Government of India, New Delhi), Installed Capacity and its Utilization in Indian Industries (Published in Paper Relating to the Formulation of Second Five Year Plan, 1955).
4. Economic Times - May 13, 1979.
5. Economic Times-May 2, 1979.
6. Annual Report of SAIL - 1977-78.
7. Financial Express - August 8, 1979.
8. Hindustan Times-December 12, 1978.

Letter to the Editor

Rather than filling pages with dead old theory, your journal ought to disseminate practical examples which alone will motivate the readers to action, which, I suppose, should be the real objective of your organ.

M. T. Abraham
3rd Nov., 1981 New Delhi

It is a well known fact that mere presence of technology and skilled manpower does not constitute technological/industrial progress unless they are supported by services like management and information. The former is well taken care of by the *Productivity*. However, coverage of the second aspect, i. e. information, is very much missing. Information, being an important resource in the creation, maintenance, and development of any industry, any industrial or post-industrial society can no more ignore it. May I, therefore, request you to occasionally cover the papers/articles on this topic.

M. M. S. Karki
22nd Dec., 1981 New Delhi

Introducing

SARDAR VALLABHBHAI PATEL AWARD SCHEME
AWARDS FOR HINDI BOOKS ON
PUBLIC ADMINISTRATION & MANAGEMENT SCIENCES

The Government of India have decided to introduce a Scheme known as Sardar Vallabhbhai Patel Award Scheme for books (original or translated) in Hindi in the fields of public administration and management sciences. The main object of the scheme is to encourage the production of standard literature in Hindi Language in these fields.

AWARDS : Three annual awards of the following amount will be given to the writers of three original books written in Hindi in the said fields :

FIRST A ward	Rs. 10,000/-
SECOND A ward	Rs. 7,000/-
THIRD A ward	Rs. 5,000/-

Two annual prizes of Rs. 3,000/- each will be given for *translations* into Hindi of standard books originally written in languages other than Hindi in the aforesaid fields.

ELIGIBILITY : The scheme will be open to all persons except those employed in the Department of Personnel and Administrative Reforms. As this is the first year of the awards, all original books published upto 31st December, 1981, manuscripts and Hindi Translations of standard books in the fields of public administration and management sciences will be considered for the awards.

SELECTION : The award-winning books will be selected by an Evaluation Committee whose decision in regard to awards will be final. All or any of the awards may not be given if the evaluation committee finds no entry meriting awards.

LAST DATE for receipt of entries is *31st March, 1982.* Entry form and further details can be had from :

Under Secretary (Admn.)
Department of Personnel and Administrative Reforms,
5th Floor, Sardar Patel Bhavan, Sansad Marg, New Delhi.

davp 561(428)81

Productivity
1981, XXII, 2, 51-57

Production Efficiency and Marketing of Himachal's Off-Season Tomato

C. S. RAGHUBANSHI
Himachal Pradesh Marketing Corporation, Simla

An attempt is made to examine the costs, returns and resource use efficiency with regard to 'off-season' tomato and to estimate the marginal value of productivity of farm inputs. The marketing margins, price spread and market integration have also been studied.

Himachal is known for growing quality "off-season" vegetables and among these tomato is the most important. It is only in the valleys that the vegetables and cereal crops can successfully be grown. These valleys-mostly of mid-hills are known for tomato cultivation. This hilly state has a low density of population (varying from 2 persons per square kilometere in Lahaul & Spiti to 167 persons per square kilometere in Bilaspur—the highest one), and urban population is only 6.99% of the total population. The vegetables have therefore to be marketed outside the State. The most important markets for Himachal's vegetables in general and for 'off-season' tomatoes in particular are located in the neighbouring states of Punjab and Haryana and the Union Territory—Chandigarh/Delhi etc. Thus, the state is a net exporter for vegetables worth several lakhs per annum. Seed potato, which is mainly grown for seed purposes fetched something like Rs. 4.00 to Rs. 5.00 crores in 1976-77 from exports to consuming states and 'off-season' tomato exports fetched about Rs. 45 to Rs. 55 lakhs during the same period.

The prospects of higher income with introduction of high yielding varieties of 'off-season' tomato gained momentum during the last decade. Although, 'off-season' tomato cultivation has amply demonstrated its better profit earning capacity, yet empirical studies pertaining to its relative performance on different sizes of farm are lacking. The 'off-season' tomato may not have same performance on different sizes of farms because of differentials in availability and application of different yield

increasing inputs. Consequently, the costs, returns, resource use efficiency, and margins of the 'off-season' tomato cultivation may be different. Therefore, an attempt is made in this paper to examine the capital needs of tomatoes growers, returns, resources use, margins and profits with the help of cost structure, output and use of various critical inputs, price spread, and market integration of 'off-season' tomatoes cultivated on different sizes of farms in an area where this crop is being grown extensively.

More specifically, the objectives of the study are :

i) To examine the costs, and returns of 'off-season' tomato on farms of different sizes;

ii) To examine the resources use efficiency with regard to 'off-season' Solan Gola variety of tomatoes on farms of different sizes and estimate the marginal value of productivity of farms inputs;

iii) To examine the marketing margins, price-spread and market integration of 'off-season' tomatoes.

Methodology

The most important 'Off-season' tomato growing areas in the State are :

Solan, Saproon Valley, Kandaghat, Ochhghat, Salogra, Shampti, Kasauli in Solan District.
Nagwain in Mandi District.
Nagrota in Kangra District.
Bhuntar and Bajaura in Kulu District.

Keeping in view the area under tomato and volume of production, Saproon Valley[1] was purposively selected for this study for the reasons given as under :

i) The valley is known for cultivation of quality produce of 'off-season' tomatoes, and covers the largest area compared with other valleys of the Pradesh.

ii) The valley's farmers are progressive and have adopted new technology for the cultivation of vegetables.

iii) Saproon is linked by a metalled road with the neighbouring Solan market and thus, adequate infra-structure facilities are readily available.

Of the 23 villages in the valley, a list of tomato growers was prepared with the help of the Patwari (i.e., a revenue official at village level) and local leaders. 98 growers were categorised in small, (below 0.75 hectares), medium (0.75—1.50 hectares) and large (above 1.50 hectares) categories. The 98 households thus categorised reported to have produced and sold major part of their tomato. Data for this research was collected from farmers and the commission agents, wholesalers, retailers etc.

The data on physical input-output of 'Off-season' tomato was collected from the selected farmers by intensive survey method pertaining to agricultural year 1974-75, on a specially structured schedule.

The costs and returns of tomato-'Solan Gola' on different sizes of farms were examined using the tabular analysis. To work out marginal value of productivity and resource use efficiency, on different size of farms, Cobb-Douglas equations were fitted using the per standard hectare data with the following variables:

where, $Y = ax_1^{b1}\ x_2^{b2}\ x_3^{b3}\ x_4^{b4}\ x_5^{b5}$.

Y = Gross returns per standard hectare in rupees comprising the value of 'Off-season' tomato sold.

X_1 = Human labour per standard hectare in rupees including all human labour used for growing tomato.

X_2 = Bullock labour per standard hectare in rupees.

X_3 = Fertilizers and manure per standard hectare in rupees comprising the value of farm produced manures computed on prevailing prices and the cost of fertilizers actually paid by the farmers.

X_4 = Insecticides/pesticides per standard hectare in rupees.

X_5 = Quality seed per standard hectare in rupees.

b_1, b_2, b_3, b_4, & b_5 are the estimates of parameters of regression equation.

Results and Discussion

To examine the relative economics of 'Off-Season' tomatoes—'Solan Gola' on different categories of sample farms, the costs and returns are worked out.

The total cost of cultivation according to size of holdings is Rs. 12,567, Rs. 13,291 and Rs. 14,689 per hectare for small, medium and large holdings respectively. However, the average cost of cultivation is Rs. 13,516 per hectare. Out of this human labour cost is Rs. 3,717 i.e. 28.08% (Rs. 3,246 family labour and Rs. 471 hired labour). Capital charges accounted for 61.87% of the total input cost, which includes land rent, land revenue, interest on capital, etc. Bullock labour occupies the second important place which costs Rs. 674 per hectare i.e. 5.09% of the total cost, followed by fertilizers and manures which constitute 2.77% of the total input cost. Insecticides and pesticides assumed the next important place in the total input cost and thus on an average the cost is Rs. 172 per hectare (i.e. 100%). The yield is 230,221 and 212 quintals per hectare in respect of small, medium and large holdings respectively. However, the average yield for all holdings is 221 quintals per hectare. It is interesting to note that tomato earned a pretty high return per hectare. On an average the total cost (Cost C) comes to Rs. 13,516 per hectare and the gross return is Rs. 23,360 per hectare, thus leaving a high margin of Rs. 9,844 as net income per hectare to the tomato growers of the valley. If the paid out cost is taken into account in order to work out the income, it comes out to be Rs. 17,801 per hectare, which is approximately one and a half times more than the net income earned over cost C. This analysis tempts one to conclude that tomato cultivation pays a good dividend to the growers. The input-output ratio of tomato for small, medium and large farms is 1.94, 1.76 and 1.52 respectively, which means that for each rupee of input invested, the gross returns are highest in small and lowest in large holdings. Thus, it leads us to conclude that the small farms are comparatively more efficient than medium and large farms. The operating ratios are 0.22, 0.23 and 0.24 for small, medium and large farms respectively which reveals that the small farms are operated more efficiently.

Production Function

The estimation of marginal value product of farm input and evaluation of resource use efficiency in growing 'off-season' tomatoes—'Solan Gola' variety are based on the equations presented in Table 1.

Regression coefficients with respective standard errors are also given in Table 1. All the independent variables namely x_1, x_2, x_4, and x_5 except that of x_3 (fertilizers and manures) are positive on all sizes of farms indicating a positive contribution of the inputs to output (Y). However, negative response to fertilizers and manures indicates excessive use of fertilizers and manures on all size of farms showing possibilities to reduce the unit cost by restricting their application to an optimal level.

The coefficient of multiple determination (R^2) indicates that approximately 84 per cent on small, 87 per cent on medium and 93 per cent on large farms of variation in the total output is explained by the independent variables considered in the function. An examination of returns to scale indicates that there were decreasing returns to scale on all size of farms. As such it is seen that one per cent increase in the level of all inputs on small, medium and large farms resulted 0.71, 0.98 and 0.92 per cent increase in the output of 'off-season' tomato respectively.

Marginal Value Productivity of Inputs

The marginal value of products (MVP) of a rupee invested on various inputs, namely human labour, bullock labour, fertilizers and manures, insecticides/pesticides and seed cost were computed at their geometric mean level for different categories of farms using the following formula :

$$MVP_x = bi \frac{\overline{Y}}{\overline{x_i}}$$

Table 1

Regression Coefficients and Marginal Value Product—Factor Cost Ratio of Different Resources on various sizes of farms

Resources	Regression Coefficients			MVP—Factor cost Ratio		
	Small (N=38)	Medium (N=44)	Large (N=16)	Small	Medium	Large
Human Labour (X_1)	0.4522** (0.2153)	0.6827** (0.3265)	0.6430** (0.2858)	2.89	4 39	3.86
Bullock Labour (X_2)	0.1468* (0.0863)	0.1876* (0.1063)	0.1893* (0.0981)	5.10	6.75	6.22
Fertilizers/Manures (X_3)	0.0085 (0.0067)	0.0223 (0.0168)	0.0261 (0.0184)	0.67	1.31	1.41
Insecticides/Pesticides (X_4)	0.0817** (0.0386)	0.0864* (0.0461)	0.0718* (0.0399)	16.43	14.97	10.85
Seed Cost (X_5)	0.0332* (0.0104)	0.0421* (0.0228)	0.0432** (0.0195)	13.03	14.48	13.23

R^2 value of the functions fitted were 0.8257, 0.8664 and 0.9321 for small, medium and large size farms respectively. Figures in parentheses denote standard error of respective coefficient.

** Significant at 5 per cent level.

* Significant at 10 per cent level.

where,

$\overline{X_i}$ is the geometric mean level of the inputs.

$\overline{Y}$ is the estimated level of returns when all the inputs are at geometric mean level.

To examine the resource use efficiency, the ratio of marginal value product to factor cost was worked out. The marginal value product (MVP) and factor-cost-ratios on small, medium and large farms are also presented in Table 1.

The marginal value product of the inputs was found to be positive in all cases except fertilizers and manures on all sizes of farms where it was found to be negative. Further, an examination of Table 1 reveals that among inputs MVP for insecticides and pesticides is highest and varies from Rs. 10.85 on large farms to Rs. 16.43 on small farms, followed by quality seed which varies from Rs. 13.03 on small farms to Rs. 14.48 on medium farms. In case of bullock labour it varies from Rs. 5.10 on small farms to Rs. 6.75 on medium farms. MVP for human labour varies from Rs. 2.89 on small farms to Rs. 4.39 on medium farms.

Marketing System

From the farmer's point of view an efficient marketing system is one which maximises his total returns from the given transaction in relation to the fact that the product market should keep on expanding. Marketing of tomatoes in Himachal is mainly controlled by private traders. This system has failed to pass on the incentives to the producers by way of backward linkage and is full of malpractices. Also the channel is through a set of intermediaries. Cooperatives have failed to provide an efficient service to the producers and have also failed to compete with the private trade. In 1969-70, *the Vegetable Growers Cooperative Marketing-Cum-Processing Society Limited, Saproon* handled only 1.13% of the total tomato trade of the valley. Over a period of six years it has declined and for the past few years it has stopped trading in this commodity. Generally, the growers bring their tomatoes in 'KILTA' (a basket containing 10 to 20 kgs.) for sale to the nearest depot (at the road-head). Some carry it to the nearest wholesale market at Solan, which is the sole collection centre for the region's produce but this market is not regulated. Supply/export meant for distant markets is packed in wooden containers. Packed weight of one such box is around 13 to 14 kgs.

Paper wastes/cuttings and dry leaves i.e. 'Kail Leaves' are used as packing material in the packaging. Each functionary renders some useful service in the process of marketing of 'off-season' tomatoes and also earns a margin of profit for himself for bearing the risk involved in this process.

Price Spread

To increase the operational efficiency[2] of the marketing system, rationalise the margins and reduce the costs, an understanding of the nature and extent of marketing margins, costs etc. is essential. Under this aspect price efficiency is examined by analysing the marketing margins and price spread in order to ascertain the margin/profit of the intermediaries i.e. whether it is reasonable and the producer is getting a fair share of the consumer's rupee. Marketing margin and price spread are measured and analysed in terms of :

i) Rupees per quintal of 'off-season' tomatoes, and

ii) percentage of consumer's price which are given in Table 2. The cost of marketing of 'off-season ' tomato is Rs. 30.87 per quintal i.e. (17.42% of the total consumer's rupee.) The functional analysis of marketing margins reveals that the retailer's share forms Rs. 15.48, Rs. 11.41 and Rs. 19.32 per quintal for sales through channels[3] I, II and III respectively accounting for 8.73%, 6.44% and 10.91% of consumer's price. Likewise the primary wholesaler/secondary wholesalers profit is Rs. 9.15 per quintal i.e. 4.66% of the consumers' price, for sales in Delhi market, whereas it is Rs. 11.05 per quintal (i.e. 6.74%) for sales in Ludhiana market. It is seen that the primary wholesalers/secondary wholesalers bear a lot of risk in advancing loans to the needy small farmers i.e. weaker section for growing tomato crop. They usually charge 15 to 20% interest.

Price Mechanism of 'Off-Season' Tomatoes Market Integration

The inter-relation between the price movements in different markets which mainly depends upon the nature and extent of competition in the market is known as 'market integration'. The degree of integration is estimated by calculating the coefficients of correlation between the monthly wholesale prices of 'off-season' tomatoes of various sample markets respectively.

It can be observed from Table 3 that the movement of prices in one market is closely followed by the price movements in other markets which has amply been testified by the presence of a high degree of positive correlation between the prices of different markets. However, proximity of these markets to each other may be attributed as another reason for movement of prices in the positive direction. Moreover, the coefficient of correlation between various markets are significant at 1%., 5% and 10% level of probability meaning thereby that some of the markets were closely influenced by and followed the price movement in other markets. However, it can also be observed from Table 3 that some of the markets are less integrated than others.

Apart from these, the positive, correlation also reveals that the movement of prices in the same direction particularly at the time of falling prices, is because of the absense of well organised institutions which could absorb excess tomato supply at a particular market period. Such an organised institution/agency could have possibly diverted excess supply to other potential markets by creating demand and could have pushed up the sales in these markets. However, 'zero market power' of the growers could be another reason for the positive correlation even in an environment of excess supply which signifies that the prices closely moved in one direction because growers could not influence the prices in the other potential markets.

Elasticity of Demand at mean level (Ed) has been worked out by multiplying the respective regression coefficients (b) by the ratio of price (p) and supply (i.e. D, quantity demanded at arithmetic mean level). Elasticity of demand was compared for 'off-season' tomatoes (or (Ed = bxp/d) at the mean level. It indicates the decrease in demand, due to 1% increase in price. The demand has been found to be highly elastic in Patiala Market (—0.0497), followed by Moga (—0.0254), Pathankot (—0.0053), Jullundur

Table 2

Costs and Margins by different channels (Average of June to October, 1974 sales)

	Item	Costs and Margins in channels (Rupees per quintal)		
		1	2	3
1.	Net price received by the producer	99.62 (56.22)	105.65 (59 62)	111.46 (62.89)
2.	Expenses incurred by the producer			
	(i) Grading and Packing	—	13.60 (7.67)	13.60 (7.67)
	(ii) Transport	—	15.15 (8.55)	15.15 (8.55)
	(iii) Octroi	—	0.62 (0.35)	0.62 (0.35)
	(iv) Loading and unloading	—	0.70 (0.40)	0.70 (0.40)
	(v) Other charges including postage etc.	—	0 80 (0.45)	0.80 (0.45)
	Total	—	30.87 (17.42)	30.87 (17.42)
3.	Producer's sale price	99.62 (56.22)	136.52 (77.04)	142.33 (80.31)
4.	Expenses incurred by the primary wholesaler/ secondary wholesaler			
	(i) Grading and packing	13.10 (7.39)	—	—
	(ii) Transport	14.00 (7.90)	—	—
	(iii) Octroi	0.62 (0.35)	0.62 (0.35)	—
	(iv) Loading and unloading	0.70 (0.40)	0.70 (0.40)	
	(v) Other costs	1.28 (0.72)	5.02 (2 83)	—
	Total	29.70 (16.76)	6.34 (3.58)	—
5.	Retailer's purchase price	155.43 (87.71)	160.55 (89.93)	142.33 (80.31)
	Marketing expenses incurred by the retailer	6.30 (3.56)	6.44 (3.63)	15.56 (8.78)
	Retailer's margin	15.48 (8.73)	11 41 (6.44)	19.32 (10.91)
	Retailer's/sale price/consumer's purchase price	177.21 (100.00)	177·21 (100.00)	177.21 (100.00)

NOTE : (i) Figures in parentheses are percentages.

(ii) Direct sales to the consumer did not exist in the 'off-season' tomatoes of the Valley.

Table 3

Correlation Matrix of Tomato Prices (1974-75)

	Ludhiana	Ferozepur	Patiala	Moga	Jullundur	Pathankot	Amritsar
Ludhiana	1 00	0.695* (0.56)	0 473 (0.420)	0.082 (0 217)	0.854*** (0.343)	0.570** (0.835)	0.482 (0.456)
Ferozepur		1.00	0.289 (0.799)	0.131 (0 350)	0.888*** (0.109)	0 301 (0.836)	0 573** (0.84)
Patiala			1 00	0.757* (0,065)	0.333 (0.934)	0.632* (0.158)	0.517** (0.60)
Moga				1.00	0 062 (0.164)	0.605** (0.010)	0.090 (0.239)
Jullundur					1.00	0.714* (0.698)	0.470 (0.409)
Pathankot						1.00	0.525** (0.632)
Amritsar							1.00

* Significant at 5% level of probability
** Significant at 10% level of probability
*** Significant at 1% level of probability

(—0.0037), Ludhiana (—0.0023), Amritsar (—0.0019) and Ferozepur (—0.0015).

NOTES

'KUHLS' provided all the water for irrigation (rain water collected on a hill-top) which worked as a perennial source of water. Thus, growers incurred no expenditure except making provision of human labour to look after the irrrigation channels.

REFERENCES

1. 'Off-season' tomato covered about 46 to 58 percent area of the total vegetable area in the Saproon Valley—the locale of this study.
2. A good marketing programme has four objectives :
   i) To carry the produce to the consumer with quality unimpaired.
   ii) To present it in attractive and readily saleable form,
   iii) To keep the costs of the various steps to minimum, and
   iv) To offer a remunerative but a fairly stable return to the grower.
3. Marketing channels involved in marketing of 'off-season' tomatoes are :
   i) Grower-Primary Wholesaler-Sub-wholesaler (i.e. Mashakhor) - Retailer-Consumer.
   ii) Grower-Secondary Wholesaler-Retailer-Consumer.
   iii) Grower-Retailer-Consumer.

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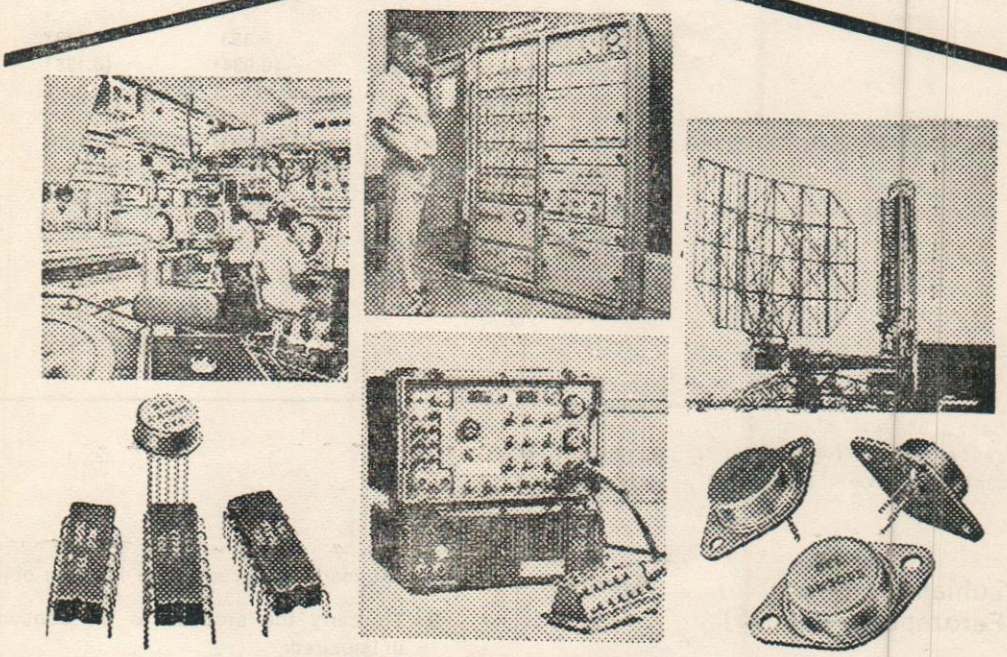

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Productivity
1981, XXII, 2, 59-64

Group Technology—Its Extension To A Scheduling Problem

P. RAMAKANTH Eicher Goodearth, Faridabad
S. RAJESHAM Indian Institute of Technology, Madras
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The Campbell-Dudek algorithm is applied to the processing of n-jobs through m-machines for all the three groups under consideration. The approach used for solving this problem involves an extension of S. M. Johnson's procedure applied to large problems.

Group Technology is a manufacturing concept which allows production of components normally produced in batches, to achieve similar economic advantages to those associated with continuous flow line production. This is achieved by organising what may appear to be a large number of diverse components into groups which require similar manufacturing process and providing the most suitable manufacturing facilities for these groups.

This paper describes the steps leading to reorganisation of a machine shop engaged in the job manufacture of Industrial Turbines into a mainly cellular system.

There have been large number of classification systems developed with varying number of objects in its code duly described by Gallagher and Knight (1). The first exercise has been to classify all the components of the end product considered. Altogether 2235 components have been classified (2) according to Opitz classification system (3,4). Three groups were then formulated from the above components by passing them through the filter of code number fields and then analysed with respect to a similar operation sequence and load capacity (5). The code number field was altered until the required machines are loaded satisfactorily and the groups adequately balanced.

Machines chosen for each group are situated together in a group layout in such a way that components flow from one machine to the next in sequence of operation. The arrangement

of machines in all the three groups had twenty machines each in the layout, with provision for dummy machines in each group and stores and warehouses in the final group (6). Based on some basic but valid assumptions, a heuristic programme was developed and the layout optimised (6).

Sequencing and Scheduling

After obtaining the optimum layout of machines, sequencing the jobs in each group was done. In the case of Group I there were 311 different jobs (713 components) and 19 machines and in the case of groups II and III, 220 different jobs (530 components), 19 machines and 289 different jobs (992 components), 10 machines respectively. The criterion used in evaluating the best sequence is minimum total processing time.

The search for a solution to the problem of finding an optimal or near optimal sequence of jobs being scheduled in a flow shop type situation was given consideration to both exact and approximate techniques of solution. Exact techniques have been developed to minimise some well defined criteria on problems involving a limited number of jobs (7, 8, 9 & 10).

Sisson (11) has pointed out that the researcher must be concerned not only with obtaining an optimal solution but also with the practical and economical application of the technique. It is the second aspect of the problem that led to the consideration of approximate methods. Another reason to investigate for approximate methods is that the procedural steps are simple enough so that the problem solver does not lose sight of the overall view of the problem.

The procedure utilised in solving the sequencing of n-jobs, m-machines problem is shown below. Not only does it permit solution of the problem far beyond the present capability of exact techniques but its effectiveness is such that companies found the approximate solution to be more economical even for those problems small enough to be handled by exact methods (12).

The Campbell-Dudek (12) algorithm is applied to the processing of n-jobs through m-machines for all the three groups under consideration. The approach used for solving this n-job, m-machine problem involves an extension of S.M. Johnson's (13) procedure applied to large problems.

The algorithm provides for the generation of upto m^{-1} sequences. Feasible sequence is accomplished in the following manner. Let T_{ji}, where $j=1, 2 \ldots n$ and $i=1, 2, \ldots m$, represent the time for processing the jth job on the ith machine in a n-job, m-machine problem. Then p, where $p\ m^{-1}$, auxiliary n-job, m-machine problem can be defined as follows :

In the kth auxiliary problem—

$$Q_{j^1} = \sum_{i=1}^{k} t_{ji} =$$ the processing time for the jth job on machine 1 (M1)

$$Q_{j^2} = \sum_{i=m+1-k}^{k} t_{ji} =$$ the processing time for the ith job on machine 2 (M2)

It should be noticed that Q^k_{ji} is the sum of processing times of job 'j' on machines 1 through k; also Q^k_{j2} is the sum of processing times of job 'j' on the last 'k' machines in the technological order. Then S. M. Johnson's n-job, 2-machine algorithm is used to determine the optimal sequences $S_1, S_2, \ldots S_p$ for 'p' auxiliary problems. The best sequence among these is chosen on the basis of minimum total processing time. Figure 1 shows the flow chart of the programme for the Campbell-Dudek algorithm.

In using the S. M. Johnson's n-job, 2-machine algorithm, let the first machine be m1 and second machine be m2. Select the smallest processing time in the two column processing time matrix, i.e. minimum of $m1_1, m1_2, \ldots m1_n, m2_1, m2_2, \ldots m2_n$. If there is a tie, select any within the tie set. However, the programme was so developed that the computer takes the first of the values within the tie set which it has read. If the minimum processing time is $m1_g$, do the g_{th} job first. If it is $m2_h$, do the hth job last. The processing times of sequenced jobs from the processing time matrix are removed in the programme by replacing them with a large value.

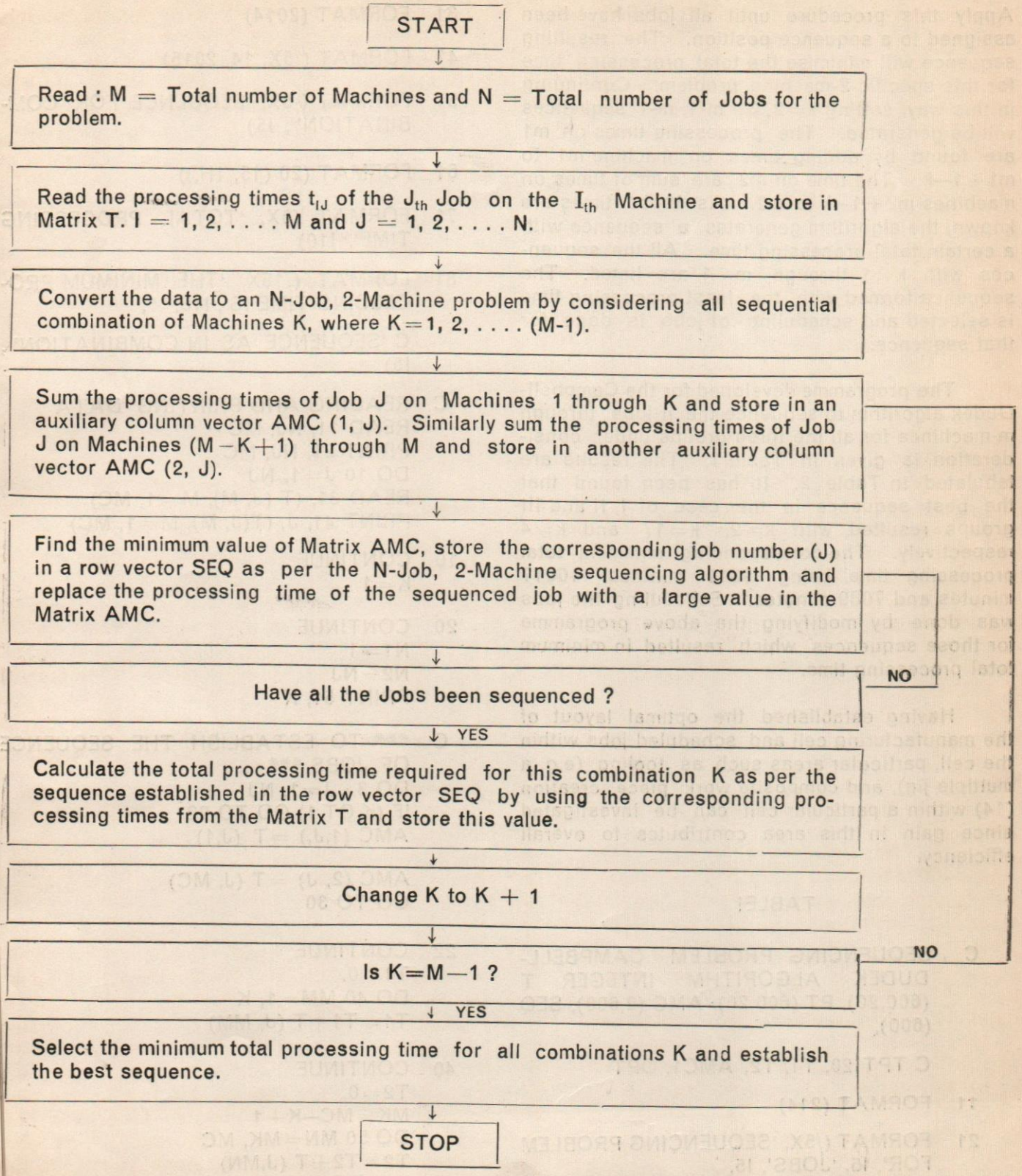

Fig. 1 : FLOW CHART FOR COMPUTER PROGRAMME INCORPORATING THE CAMPBELL-DUDEK ALGORITHM.

Apply this procedure until all jobs have been assigned to a sequence position. The resulting sequence will minimise the total processing time for this specific 2-machine problem. Continuing in this way, setting k=2, 3...m-1, m-1 sequences will be generated. The processing times on m1 are found by adding times on machine m1 to m1+1—k. The time on m2 are sum of times on machines m2+1—k to m2. As these times are known, the algorithm generates a sequence with a certain total processing time. All the sequences with k=1 through m—1 are listed. The sequence formed with the least processing time is selected and scheduling of jobs is done for that sequence.

The programme developed for the Campbell-Dudek algorithm to sequence the n-jobs through m-machines for all the three groups under consideration, is given in Table 1. The results are tabulated in Table 2. It has been found that the best sequence in the case of I, II and III groups resulted with k=2, k=17 and k=4 respectively. The corresponding minimum total processing time being 9811 minutes, 10017 minutes and 7089 minutes. Scheduling the jobs was done by modifying the above programme for those sequences which resulted in minimum total processing time.

Having established the optimal layout of the manufacturing cell and scheduled jobs within the cell, particular areas such as tooling (e.g. a multiple jig), and composite work piece creation (14) within a particular cell can be investigated since gain in this area contributes to overall efficiency.

TABLE I

```
C   SEQUENCING PROBLEM CAMPBELL-
    DUDEK ALGORITHM INTEGER T
    (600,20), PT (600,20), AMC (2,600), SEQ
    (600),
C   TPT 20, T1, T2, AMC1, OPT
11  FORMAT (214)
21  FORMAT (/5X, 'SEQUENCING PROBLEM
    FOR', I5, 'JOBS', I5,
    'MACHINES' /56 X,
C   'THE GIVEN DATA' /5X, 'JOBS', 50X,
    'MACHINES')
31  FORMAT (2014)
41  FORMAT (/5X, 14, 2015)
51  FORMAT (/5X, 'SEQUENCE FOR COM-
    BINATION', I5)
61  FORMAT (20 (15, 1H,))
71  FORMAT (5X, 'TOTAL PROCESSING
    TIME', I10)
81  FORMAT (/15X, 'THE MINIMUM PRO-
    CESSING TIME IS', I16, ' ',
C   'SEQUENCE AS IN COMBINATION',
    I5)
C   READING AND PRINTING DATA
    READ 11, NJ, MC
    PRINT 21, NJ, MC
    DO 10 J=1, NJ
    READ 31, (T (J, M), M=1, MC)
    PRINT 41, J, (T(J, M), M=1, MC)
10  CONTINUE
    K=1
20  CONTINUE
    N1=1
    N2=NJ
    PRINT 51, K
C   *** TO ESTABLISH THE SEQUENCE
    OF JOBS ***
    DO 3  J=1, NJ
    IF (K.GT.1) GO TO 22
    AMC (1,J,) =T (J,1)
    AMC (2, J) =T (J, MC)
    GO TO 30
22  CONTINUE
    T1=0.
    DO 40 MM=1, K
    T1=T1+T (J, MM)
40  CONTINUE
    T2=0.
    MK=MC—K+1
    DO 50 MN=MK, MC
    T2=T2+T (J,MN)
50  CONTINUE
    AMC (1, J)=T1
    AMC (2, J)=T2
```

```
 30  CONTINUE
300  CONTINUE
C    TO FIND THE MINIMUM VALUE OF
     AMC
     DO 60 M=1, 2
     IF (M.EQ.1) J1=1
     IF (M.EQ.2) J2=1
     AMC1=AMC (M,1)
     J=2
 63  CONTINUE
     IF (AMC1. LT. AMC (M,J) ) GO TO 62
     IF (M.EQ.1) J1=J
     IF (M.EQ.2) J2=J
     AMC1=AMC(M,J)
 62  CONTINUE
     J=J+1
     IF (J.LE.NJ) GO TO 63
 60  CONTINUE
C    TO STORE THE SEQUENCE OF JOBS
     IF (AMC (1,J1).LT.AMC(2,J2))GO TO 32
     SEQ (N2)=J2

     N2=N2—1,
     AMC (1,J2)=1. OE+10
     AMC (2,J2)=1. OE+10
     GO TO 33
 32  CONTINUE
     SEQ(N1)=J1
     N1=N1+1

     AMC (1,J1)=1. OE+10
     AMC (2,J1)=1. OE+10
 33  CONTINUE
     IF (N1—1). NE. N2) GO TO 300
C    *** TO ESTABLISH THE PROCESSING
     TIME REQUIRED ***
     KJ=SEQ(1)
     PT (1, 1)=T (KJ, 1)
     DO 70 M=2, MC
     PT (1, M)=PT(1, M—1)+T (KJ,M)
 70  CONTINUE
     J=2
 83  CONTINUE
     KJ=SEQ (J)
     PT (J,1)=PT (J—1, 1)+T (KJ, 1)
     DO 80 M=2, MC
     IF (PT(J—1,M).GT. PT (J,M—1) ) GO
     TO 82
     PT (J,M)=PT (J, M—1)+T (KJ,M)
     GO TO 80
 82  CONTINUE
     PT (J,M)=PT (J—1,M)+T (KJ,M)
 80  CONTINUE
     J=J+1
     IF (J.LE.NJ) GO TO 83
     TPT (K)=PT (NJ,MC)
     PRINT 61, (SEQ(J), J=1, NJ)
     PRINT 71, TPT (K)
     K=K+1
     IF (K.LT.MC) GO TO 20
C    *** TO FIND THE GLOBAL MINIMUM
     OF PROCESSING TIMES
     K=2
     KS=1
     OPT=TPT (1)
 92  CONTINUE
     IF (OPT.LT. TPT (K) ) GO TO 90
     OPT=TPT (K)
     KS=K
 90  CONTINUE
     K=K+1
     IF (K.LT.MC) GO TO 92
     PRINT 81, OPT, KS
     STOP
     END
```

Table 2

Group	Number of Components (Jobs)	Number of Machines	TOTAL PROCESSING TIME FOR EACH VALUE OF 'K'																
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
I	713 (311)	19	15323	13513	13295	13138	12668	12151	11082	11762	11585	10252	9902	9811	10011	10174	10428	10521	10421	11073
II	530 (220)	19	21656	16514	15328	14284	13448	11989	11586	11786	11696	11172	11692	11778	11371	11493	10977	10947	10017	11517
III	992 (289)	10	8274	8274	7464	7089	7390	7531	7518	7631	7361	—	—	—	—	—	—	—	—	—

Conclusions

Application of cell system of production in the particular industry for manufacturing turbines will yield the following results :

1. Reduced throughput times.
2. Reduced work-in-progress.
3. Reduced material handling cost.
4. Reduced setting time.

REFERENCES

1. C. C. Gallagher and W. A. Knight, *Group Technology*. London : Butterworths and Co., 1973.
2. P. Rama Kanth, M. Tech. Thesis, I. I. T., Madras 1976.
3. H. Opitz, *A Classification System to Describe Workpieces*. Oxford : Penguin Press, 1970.
4. H. Opitz, and H. P. Wiendahl, *Int. J. Prod. Res.* Vol. (9), 1971 pp. 181-203.
5. S. Rajesham, P. Rama Kanth and V. C. Venkatesh, Proc. 7th AIMTDR Conf. 1976 pp. 249-252.
6. P. Rama Kanth, S. Rajesham and V. C. Venkatesh, Proc. Indo-British Conf. Engg. Prodn. 1976. pp. E-37-41.
7. Dudek, Richard and Teuton, *OR, Vol.* 12, No. 3 1965, pp. 471-497.
8. Ignall, Edward and Schrage, *OR Vol.* 13 No. 3 1965, pp. 400-412.
9. W. Karush, OR. Vol. 13, No. 3, 1965 pp. 323-325.
10. Smith, Richard and Dudek, *OR. Vol.* 15, No. 1 1967. pp. 71-82.
11. R. L. Sisson, *Progress in OR*, John Wiley and Sons Inc., 1961, pp. 295-325.
12. Campbell, *Management Science Journal, Vol.* 16, No. 10, June 1970.
13. S. M. Johnson, *Nav. Res. Log. quarterly*, No. 1 March 1954 pp. 61-68.
14. S. P. Mitrafanov, *The Scientific Principles of Group Technology*, National Lending Library Translation, Yorkshire, 1966.

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Non Neutral Technological Progress in Mineral and Metal Group Industry

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Three types of technological progress are recognized by economists viz. neutral, labour saving and capital saving. The study examines the bias in technological progress of six important industries at All-India level during the period 1960 to 1973.

Technological Progress is one of the most important factors responsible for economic growth. Solow (1957) mentioned that technological change can be ascertained from shifts in the Production function. Different types of technological change have been known viz. embodied or disembodied technical change and neutral and non-neutral technical change. The neutral technological change is neutral with respect to the relative use of factors like labour and capital. Non-neutral or biased technological change may be either labour saving (capital using) or capital saving (labour using). It alters the intensity and ease of substitution between factors.

In case of biased technological progress, the nature of bias is indicated by the time-series graph of the distribution parameter δ of the CES function. A sustained increase in δ would indicate capital using technological progress while a sustained decrease, a capital saving technological progress (Ferguson, 1965).

The industries which we call Mineral and Metal based group (MM group) in the present analysis are as follows.

		SIC Group No.
1.	Basic Industrial chemical including fertilisers	311
2.	Non-metallic Mineral Products	33
3.	Non-ferrous basic metals	342
4.	Metals except Machinery	350
5.	Machinery except electrical	360
6.	Electrical Machinery	370

Methodology

The constant Elasticity of substitution production function (CES) which is of the form given below has been fitted to the data of the above industries for the period from 1960 to 1973.

$$V=\nu\left[K^{-\rho}+(1-\delta)L^{-\rho}\right]^{-1/\rho} \quad \ldots\ldots(1)$$

Where V is value added,

K is fixed capital,

L is Total man hours,

and ν, δ, and P are constants which Arrow et al (1961) call as the efficiency, distribution and substitution parameters respectively.

The above equation is linearly homogeneous in the two generalised inputs of K and L. From the equation (1) the marginal product of Labour $\frac{\delta V}{\delta L}$ and marginal product of capital $\frac{\delta V}{\delta K}$ can be derived as follows :

$$\frac{\delta V}{\delta L}=-\frac{\nu}{\rho}(1-\delta)L^{-(1+\rho)}\left[\delta.K^{-\rho}+(1-\delta)L^{-\rho}\right]^{\frac{-1+\rho}{\rho}} \quad (2)$$

$$\frac{\delta V}{\delta K}=-\frac{\nu}{\rho}.\delta.K^{-(1+\rho)}\left[\delta.K^{-\rho}+(1-\delta)L^{-\rho}\right]^{\frac{-1+\rho}{\rho}} \quad \ldots\ldots(3)$$

The marginal rate of technical substitution (s) is the ratio of the two marginal products. In competitive equilibrium, it must be equal to the factor price ratio. So, denoting real wage rate as w and the rate of return of capital by 'r' we obtain

$$S=\frac{w}{r}=\frac{\nu(1-\delta.K^{1+\rho}}{\nu.\delta.L}=\frac{1-\delta}{\delta}.\left(\frac{K}{L}\right)^{1+\rho} \quad \ldots\ldots(4)$$

$$\log_e S=\log_e\left(\frac{w}{r}\right)=-\log_e\frac{\delta}{1-\delta}+(1+\rho)\log_e(K/L) \quad \ldots\ldots(5)$$

So by rearranging we get

$$\log_e\frac{\delta}{1-\delta}=\log_e\left(\frac{r}{w}\right)+(1+\rho)\log_e(K/L) \quad \ldots(6)$$

From equation (6), it is clear that the nature of the biased technological progress may be reflected by changes in δ. For given values of r, w, and ρ an increase in δ would lead to an increase in the Capital/Labour ratio and vice versa. Thus change in δ depicts Harrod's definition of Non-neutral technological change. Similarly, for a constant Capital/Labour ratio, an increase in δ increases the marginal product of Capital relative to that of labour, and vice versa and this is precisely Hick's definition of non-neutral technological progress. The information as to whether δ increases or decreases over the period under study can therefore be used for inferring the nature of biased technological progress.

The sources of data are from various issues of Annual Survey of Industries. The study period is from 1960 to 1973. The money values of fixed capital, total wages and salaries, and value added have been taken in real terms after taking into account price changes.

Results and Conclusion :

Figures 1 to 6 show the time series of δ graph in respect of MM group industries at All India level. The nature of bias in technological progress has been inferred from Fig 1 to Fig 6 by observing the year to year changes in δ values. The nature of bias so estimated for MM group industries is presented in Table I.

Table I

Nature of technological progress in MM group industries in different years at All India level.

Industry	Capital using	Capital saving
1. Basic Industrial chemicals including fertilisers	1960-1965 and 1968-1971	1965-1968
2. Non metallic mineral products	1960-1973	—
3. Non ferrous basic metals	1960-1967	1967-1971
4. Metals except Machinery	1960-1962 and 1966-1969	1962-1966 and 1969-1973
5. Machinery except electrical	1966-1973	1960-1966
6. Electrical Machinery	1962-1973	1960-1962

YEARLY DISTRIBUTIGN OF δ
BASIC INDUSTRIAL CHEMICALS

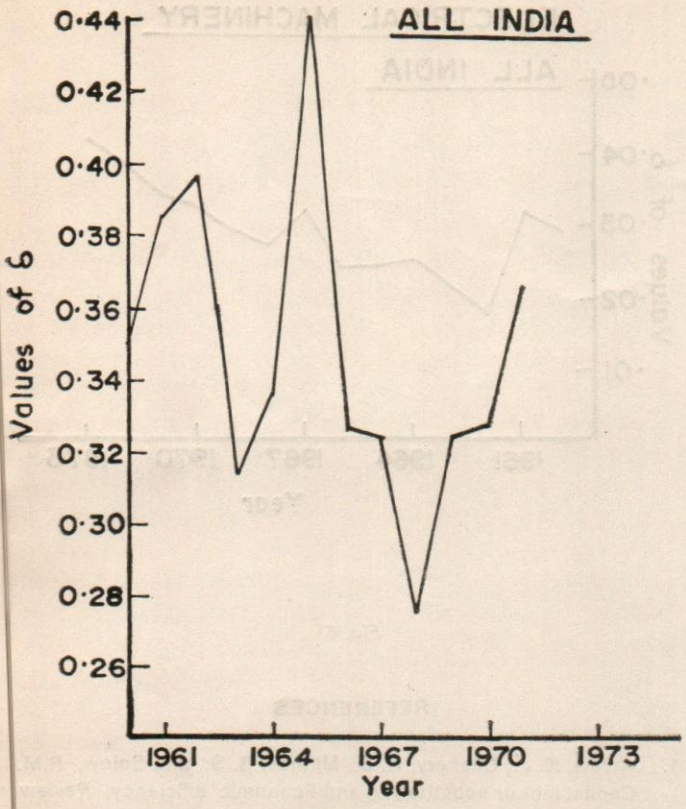

Fig. 1

NON METALLIC MINERAL PRODUCTS

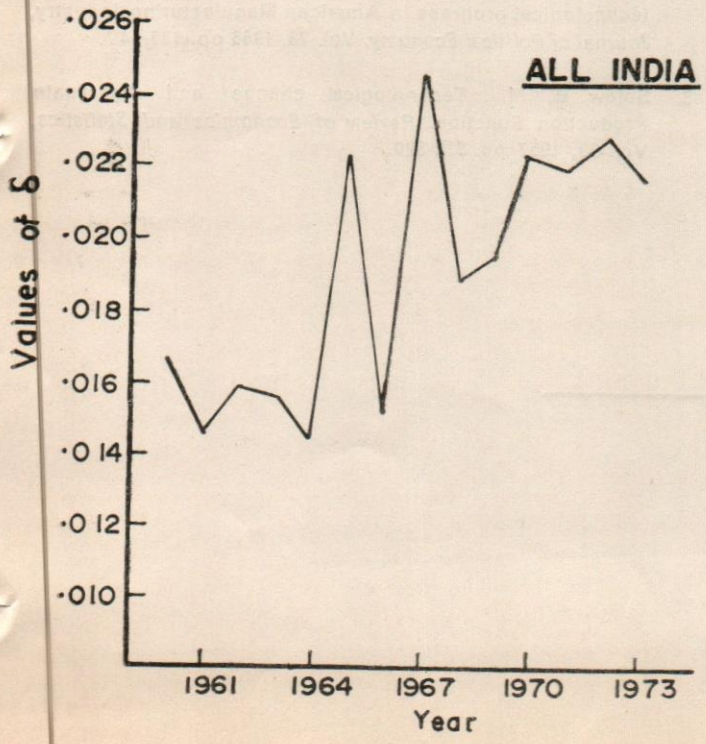

Fig. 2

YEARLY DISTRIBUTION OF δ
NON-FERROUS BASIC METALS

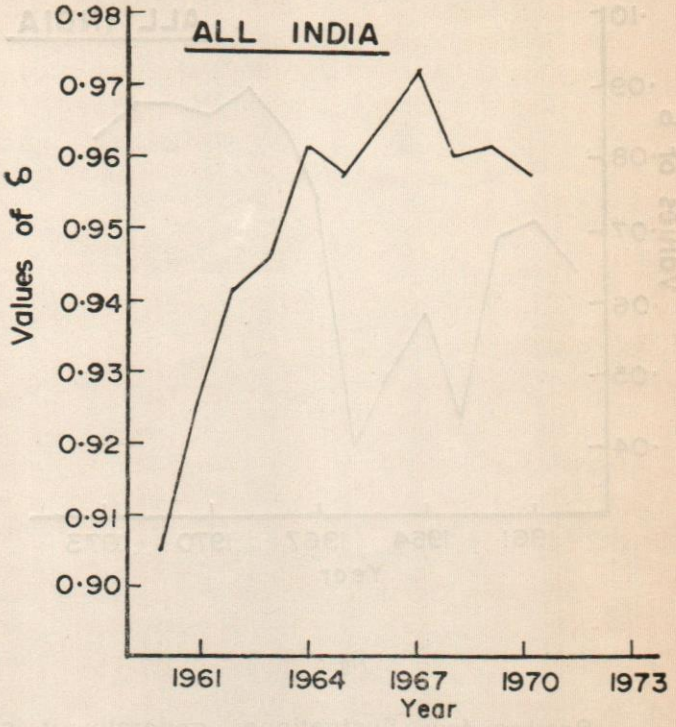

Fig. 3

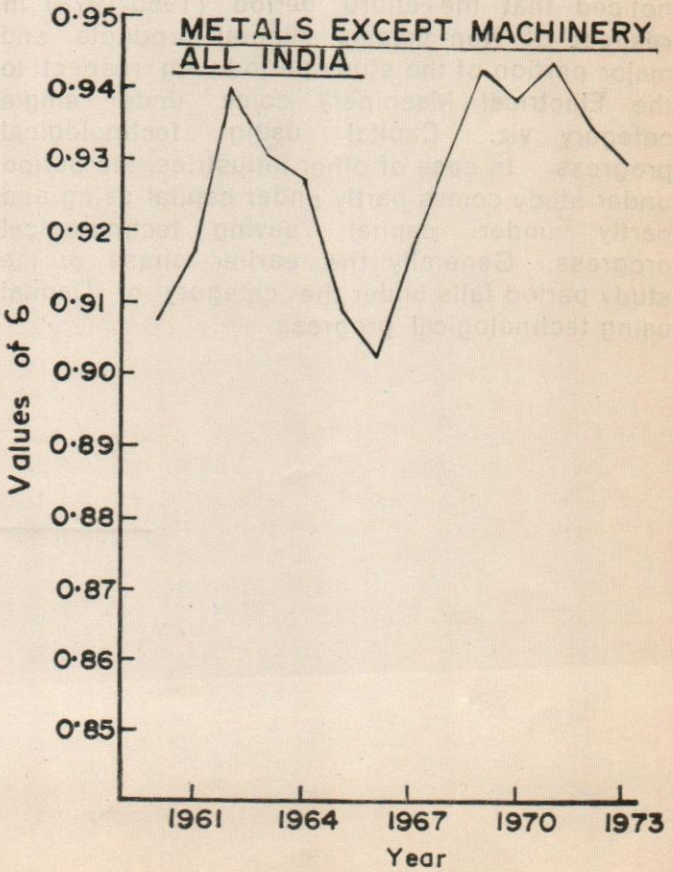

Fig. 4

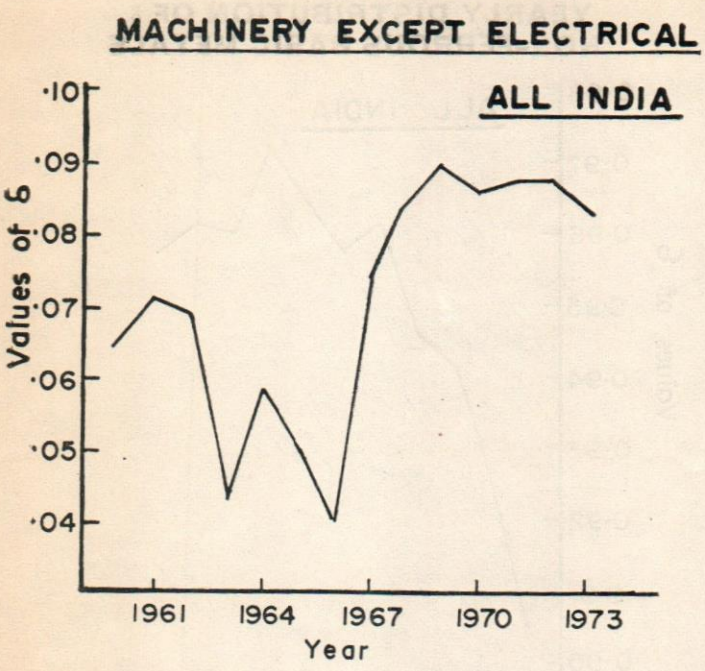

Fig. 5

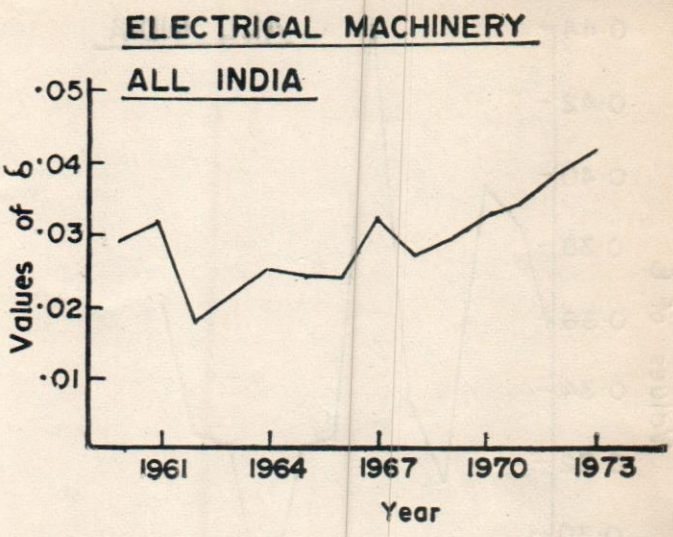

Fig. 6

Barring few fluctuations, generally it is noticed that the entire period (1960-1973) in respect of Non-metallic mineral products and major portion of the study period with respect to the Electrical Machinery come under single category viz. Capital using technological progress. In case of other industries, the period under study comes partly under capital using and partly under capital saving technological progress. Generally the earlier phase of the study period falls under the category of Capital using technological progress.

REFERENCES

1. Arrow, K. J., Chenery, H. B., Minhas, B. S., and Solow, R.M. Capital labour substitution and Economic efficiency, *Review of Economics and Statistics*, 43(3) 1961 225-250:

2. Ferguson, C.E. Time series Production functions and—technological progress in American Manufacturing Industry, *Journal of Political Economy*, Vol. 73, 1965 pp. 135-147.

3. Solow, R. M. Technological change and Aggregate Production Function, *Review of Economics and Statistics*, Vol. 39, 1957 pp. 312-320.

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EXECUTIVE READINGS

The New Agrarian Technology and India

Biplab Das Gupta

New Delhi : Macmillan Co. of India Ltd., 1980.

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Ever since Independence the problem of stabilising agricultural production and then increasing the same at a steady rate has been a thorn in the flesh of Indian Planners. The introduction of the 'new agricultural strategy' by way of using high yielding varieties (HYV) has provided some fruitful results. But the question of whether this can be termed a revolution on the agriculture front has been the subject of considerable research. The book under review incorporates the findings of one such study conducted by Das Gupta. The main objective of the study according to the author is to examine the 'social and economic consequences of the introduction of high yielding varieties of foodgrains in India.

The study is based on 7 micro level studies covering 8 states, 10 districts and 32 villages and a wide variety of ecological and agro-economic conditions.

During 1966 and 1971 there was a rapid increase in the area under HYVs and in the average foodgrain production and a decline in imports. The second phase 1971-75 was characterised by unfavourable weather conditions. This led to the decline in the yield rates, more dependence on imports, and failure of harvest. Famine conditions were visible again in the various parts of the country. The third phase 1975-76 witnessed the best ever foodgrain production in the country thereby bringing an end to stagnation and less dependence on weather. However, the author has shown that, inspite of considering the period when HYV seeds were introduced, the rate of growth in food production between 1965-76 was only 2.3%. This is less than the rate of growth for the period 1951-65 when it was 3.5%. This is a major indicator of the fact that the introduction of new technology is hardly revolutionary in character. However, it has prevented large scale starvation and famine. Even today agriculture in India is a prey to the unpredictable monsoon. Though the HYV wheat seeds have fared better in the northern states of the country, HYV rice seeds have been vulnerable to insects and pests. Moreover, variability of their output over different lands and regions is quite high. This is one of the reasons for low increase in rice production. Similarly, the high yielding varieties for crops like maize, sorghum and millet have also suffered from the high variability of output due to their susceptibility to pest attacks. The so-called miracle seeds are responsible for a number of problems :

a) The high turnover rate of the varieties in case of rice and hybrid varieties. This is because old ones are replaced by new ones over a period of 2 to 3 years with the result that the

farmer has to revise the crop calender and learn a new set of agricultural practices every time the change is made.

b) The new varieties require regular renewal whereas the traditional farmer is not used to buying seeds.

c) The new seeds are often of low quality, due to inadequate germination tests and seed treatment arrangements and due to lack of proper machinery for the certification of seeds.

In addition, the use of modern agricultural inputs like fertilisers, pesticides and herbicides, use of tractors, threshers, harvesters etc., are not within the easy reach of an average farmer. Thus it is only the rich farmers who can afford the use of modern techniques who benefits rather than the small farmer who has to pay a higher price in hiring the services of a tractor or a harvestor. Moreover, if the distribution of tractors and other inputs is considered it can be seen that they are available with rich farmers in states like Punjab, Haryana, UP and in some parts of Andhra Pradesh and Tamil Nadu. Another reason for the failure of the new agricultural strategy is the lack of facilities provided by the cooperative societies in rural areas.

What is required as a remedial measure is to bring more land under new HYV seeds alongwith inputs like fertiliser, pesticides, use of tractors etc.. Most important, however, is a change in attitude of the farmers leading to a revolution in thought and ideas. In the meantime, it is necessary for the government to ensure that proper land distribution legislation is brought about so as to abolish the tenants and help the landless with a piece of land and avoid economic concentration of power (whether it be financial or land holding).

Das Gupta has dealt with these problems in detail and given a good account of the factors that have nullified the gains of the agricultural revolution brought about in the 1960s and 1970s. The book is a welcome addition to the existing literature on the subject and would be useful to students and scholars alike. □

Productivity, Production Function and Technical Change

S. S. Mehta

New Delhi : Concept Publishing Company, 1979.

Reviewed by N. K. Nair
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This volume is a revised version of the author's Ph. D dissertation, submitted to the Gujarat University in 1976. The study attempted to measure technological change in 27 large-scale Indian Industries during 1953-65. The work, as the title suggests, is an addition to the innumerable studies undertaken within the neo-classical frame of analysis based on CMI-ASI data. There is, therefore, nothing new the study can convey by way of either methodological improvements or, information. The questions discussed are : Is technical change taking place ? If yes, what is its contribution to growth of output ? What is the nature of the observed technical change ? And is the direction of technical change consistent with country's resources and factor endowements ? The study had covered trends in partial and total factor productivity indices, inter industry correlation and parameters of Cobb-Douglas and CES production functions. The reason for using all these methods of measuring technological changes is that technical progress cannot be measured precisely, only its broad trends can be traced. Each of these methods explains some components of technological change which are utilized for building the entire picture. Terms like 'technological change,' 'technical progress,' etc. have been extensively used by the author, without stating any clear distinction.

The study has adjusted CMI-ASI data and made them consistent both with respect to coverage and classification at a disaggregated level. Chapter 1 of the book deals with concepts, data and methods. Chapter 2 explains partial and total factor productivity indices which use the ratio analysis to measure the movement of technological progress or productivity. Chapter 3 first maps out the growth profile of all the 27 industries and examines the trends in partial and total factor productivity indices.

Chapter 4 presents the results of a cross-sectional inter-industry analysis carried out for 27 manufacturing industries from 1963 to 1965. Chapter 5 details the production function approach for measuring the technological change. Chapter 6 examines the sources of output growth through Cobb-Douglas production function and Klien-Kosbud method of factor shares. The parameters of Cobb-Douglas and CES production functions are estimated to test the hypothesis of constant returns to scale. In Chapter 7 the elasticity of substitution is estimated using alternative formulations derived from CES production function. Chapter 8 reviews the various conclusions of the study. A Post-Script has been added to examine trends in productivity in the post 1965 period using the latest available data.

Major conclusions reached by the author are :

(1) Improvements in productivity have not led to improvements in wage rates of reduction in prices but improvements in rates of surpluses to the owners of capital.

(2) Performance of some industries like bicycles, glass and glassware and electric fans were fairly satisfactory, whereas in the traditional industries like cotton textiles, jute textiles, matches and sugar overall efficiency has declined.

(3) Most industries, of late, exhibit constant returns to scale.

(4) Growth in labour productivity in many industries is not due to capital intensity.

(5) Elasticity of substitution is found to be significantly different from zero and one in many industries.

(6) Rate of technological change in growth process of Indian industries is not very significant. Technological progress, unlike in developed countries, has not been a contributory factor in Indian Industrial growth.

The reviewer, on more than one occasion, is led to infer that the author's conclusions are more a result of his intution and impressions than the outcome of a rigorous quantitative exercise. Neverthless, the book could be treated as another addition to industry level growth and productivity studies which may be of help for researchers in economics. □

Sugar Cane Production in Asia

Symposium on Sugar Productivity, 1979, Tokyo : Asian Productivity Organization, 1980.

Reviewed by B. H. Lalvani, New Delhi.

The book documents the proceedings of the symposium held in Tokyo in 1979 on sugar productivity in member countries of Asian Productivity Organisation. The sugar industries in this region like their counterparts elsewhere have felt the impact of fall in prices and rise in the cost of inputs due to escalating price of oil. The objective of the symposium therefore was to expedite transfer of technology through a cooperative undertaking among the members countries of APO, to exchange experiences, compare technologies and strengthen the competitive standing of sugar vis-a-vis other export commodities.

The world sugar industry is reeling from the effect of world-wide inflation and low sugar prices. The price of agricultural inputs have risen in inverse proportion to the prices of sugar in world market. About 10 to 15% of the world's annual production representing a surplus with the exporting countries finds its way to the world markets and accounts for 50% of the world's total sugar export trade. The rate of increase in sugar production in Asia will be determined more by domestic consumption than by export demand which is moderated by International Sugar Agreement aimed at maintenance of world sugar prices at remunerative levels for the exporters and fair and reasonable levels for the importers through export quotas and buffer stocks.

Production responses to supply prices in Asia tend to be relatively more elastic than other sugar producing regions. Marginal land under sugar cane cultivation in Asia (excepting Phillipines) could be put under alternate crops. Other factors of recent origin that could influence the price levels in world market in sugar

are increasing production of sugar cane for conversion into ethanol as a supplement to fossil energy fuels in developing countries and increased competition to sugar from fructose corn syrup (HFCS) in the developed countries. The outlook for Asian sugar trade could improve by organising special sugar trading arrangements on the lines of EEC and COMECON.

According to FAO, 22 sugar cane growing countries in Asia produced about 32 million metric tonnes of sugar in 1977 on 5.8 million hectares of sugar land accounting for 50% of the world's production. India, China, Pakistan, Phillipines, Thailand and Indonesia are among the most important growers. The difference in per hectare yield in the different producing countries in the region are due to a variety of factors. The high yielding group of countries like Iran, Indonesia and China are situated either in tropical areas or areas receiving better solar radiation (Iran). Larger portion of Northern India, Western Pakistan and Nepal are less favourably situated in this respect. Land surplus countries like Thailand and Phillipines have lower proportion of irrigated land and low yields. On the other hand, China and Indonesia have higher proportion of irrigated land and higher yields. India with 70% irrigated land still has low yields like Thailand and Phillipines where only 5 to 10% land under sugar is irrigated. India's major yields differences arise more due to environmental factors which cannot easily be closed by R & D. The differences due to cultural practices are exemplified by Pakistan and Iran which exhibit yield difference of 65 mt/ha in favour of Iran under similar environmental conditions and with 100% irrigation. The yield difference of 40-50 mt/ha among China, Thailand and Phillipines having similar environment is due to differences in irrigation and cultural practices. For any of the Asian countries to approach or surpass China (Republic) in the production levels will require substantial investment in irrigation.

Land is the most important constraint with the most inelastic supply. Countries with severe constraint on sugar land should try to maximise the returns by suitably tailored research programmes. Another means under conditions of limited land is to increase ratoon productivity and to shorten the period of ratooning but this is feasible only where labour is abundant. A third and common alternative is to increase the area under irrigation permitting higher yields from a single crop and in some cases from multicropping. Republic of China and Indonesia have higher land under irrigation and higher yields than land surplus Thailand and Phillipines. Shortening the cropping period offers potential in raising output levels in the face of limited sugar cane land in most of the member countries. Advance in breeding techniques including the development of tissue culture technique and shortening the breeding cycle from 10-12 years to a 6 year cycle are other ways of achieving the same objectives.

An increase in transportation efficiency is needed to provide adequate returns to small and medium sized producers in Pakistan, India and Indonesia so that they can continue to supply their produce to the mills. It was agreed that sugar cane increase in production in most of Asia can be achieved by existing sugar lands and mills rather than by expansion of areas and new sugar processing facilities as the costs will be uneconomic at projected price levels. Large scale investments in irrigation and drainage were not advised given the depressed prices of sugar unless they could simultaneously service other crops as well. The outlook for increasing both sugar cane and sugar yields for most countries with yield below 60 mt/ha was promising.

The economic and social problems of Asian sugarcane production are varied. They include a lack of credit for the farmers and millers to adopt available technologies, a shift away from sugar cane to alternative crops, overdependence in rural areas on sugar cane production and sugar milling for employment, minimum wage legislation which encourages premature mechanisation of certain farming operations and increases the total wage bill in the current period of very low returns and a lack of suitable equipment to relieve the drudgery of field-labour. Simple and effective methods of sugar pricing need to be devised to provide incentive to both farmers and factories to improve sugar yields as these require very little, if any, additional labour inputs. □

Accounting Education in Economic Development Management

Adolf J. H. Enthoven

Amsterdam : North-Holland Publishing Company, 1981.

Reviewed by P. Chattopadhyay, Calcutta

A new dimension to accounting thought, accounting education and accounting research has been opened up by Professor Adolf J. H. Enthoven since the publication of his first study on *Accountancy and Economic Development Policy* (1973). He himself has followed it up with subsequent titles like *Accountancy Systems in Third World Economies (1977)* and *Accounting Education and the Third World* (1978). The last one was in fact, a Report of the Committee on International Accounting Operations and Education of the American Accounting Association. The present book, therefore, forms part of a series emphasizing the consistency of the ideas developed by Professor Enthoven and providing a comprehensive outline for formulating a framework of accounting education on an international scale.

The intellectual discipline of accountancy is, like many other disciplines, multifaceted. Each of these facets has been given varying degrees of importance, not only in different countries of the developed and developing world but also at different levels of education such as professional accounting bodies, universities, undergraduate level accountacy education and as a vocational stream enabling pursuers to get suitable jobs in various organizations. Several new linkages have been established by Professor Enthoven with reference to the significance of accountancy and accounting education at levels starting from national accounting down to the level of micro-unit accounting involving different sectors of the economy, different activities pursued in these sectors and different aspects of operations sought to be highlighted.

The immediate relevance of accountancy for economic development stressed by Professor Enthoven has been widely recognized and has led to the evolution of an almost new branch of accountancy, namely, eco-development accounting.

Professor Enthoven has sought to present in these volumes not only a theoretical exposition of what accounting stands for and how accountancy education should be designed for realizing the objectives but also the country-viewpoints and organisation-viewpoints covering government, public sector and private sector organisations engaged in the production of both tangible products and intangibles such as services. Professor Enthoven has consistently stressed the need for identification of accounting expertise and experience in both developed and developing countries for their extension to those countries where these have been somewhat unknown and untried.

This book is in four parts. In part one, covering four chapters, the author has presented an overview of the significance and linkages of accounting and economic development. Part two, having three chapters, underlines the role and significance of accounting education in third world countries, highlighting the characteristic elements of an accounting educational programme for economic development. Part three, outlining a framework for accounting education action, has seven chapters, the last presenting a summary and conclusions arising out of the action programme suggested. Among the accounting infrastructure improvements required, in his view, are :

(a) the need for an Institute with related professional activities for evaluating the status of accountants developing accounting and auditing standards, establishing codes of conduct, supervising professional training and updating, guiding research, disseminating reading materials and acting as a clearing house for activities.

(b) streamlining the legal and regulatory framework having a bearing on accountancy profession and accounting education.

(c) formulation of an 'accounting inventory' which should include, in his view, a layout and an analysis of (i) the activities of an accountant at various functions and levels, (ii) the current legislative and institutional set up and (iii) the educational and training elements. It would also

stic of agricultural labourers". And one suspects that almost all these people are those who belong to the sections of landless labourers and very small cultivators and have joined the ranks of traders because of no restriction on entry in to it, as noted above. However, the number of families below the poverty line engaged in trade of pumpsets, wholesaling, fertiliser dealing and milling is negligible.

This inded is a scholarly work and the author through empirical data throws interesting light on the emergence of trade and trading capital in agriculture and the role it is playing in the development of this sector. It would be of value if similar studies are also undertaken in North-Western India—Punjab and Haryana—where transformation in the farm sector has been much faster than anywhere else in India. □

Handbook of Industrial Law

N. D. Kapoor

New Delhi : Sultan Chand & Sons, 1980.

Based on the review by Prem Govil.

University of Delhi, Delhi.

The history of Indian Legislation is now over a 100 years old and dates back to 1860 when the Apprentices Act was enacted, followed by the Fatal Accident Act in 1855, the Workmen Breach of Contract Act in 1859 and Employers and Workmen Disputes Act in 1860. After Independence, there was a tremendous increase in the volume of labour legislation. In the Constitution of India, the subject of labour was placed in the concurrent list, permitting both the central and state Governments to enact labour laws. The basis for suitable legislation was provided by Article 43 of the Constitution which states :

> "The state shall endeavour to secure by suitable legislation or economic organisation, or in any other way, to all workers, agricultural, or otherwise, work, a living wage, conditions of work, ensuring a decent standard of life, and full employment of leisure, and social and cultural opportunities....."

The book under review is a fairly comprehensive one and quite exhaustive in its contents and coverage. The author has made a good attempt at reproducing statutes made by Parliament, their amendments, if any, by states, Rules and Case Notes of important decisions. The National Commission of Labour assessed the working of the existing legislation and made a number of recommendations for ensuring greater protection of the worker's interest. The author has, commendably, incorporated these recommendations in connection with the concerned legislation.

The book covers almost the entire gamut of industrial law. Care has been taken to select and include all cases and precedents of legal significance. The author has used an easily understandable style but has been careful not to overlook any important legal issue. A welcome feature is the illustration from practical life, designed to impress the significance of a particular statutory provision. This has helped to make the book interesting to read in addition to being highly informative.

Test questions have been added at the end of every chapter to help the reader check on his own understanding of the statutory requirements. The author has also raised a number of practical points for the reader to ponder upon. Hints and guidelines to the solutions of some of these problems have been provided.

The book appears to be quite adequate in its scope and coverage. Labour practitioners, Managers, trade unionists, postgraduate students and all concerned with Industrial Law should find it quite useful in dealing with day-to-day business as well as for solving more intricate and complicated problems. □

Productivity
1981, XXII, 2, 77-82

Poverty and Irrigation

A. A. RANE
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The study indicates that about 61% of the population of unirrigated villages lives below the poverty line. These people are unable to satisfy even 50% of their minimum requirements. They are undernourished and suffer from malnutrition... Government should first pay attention to this very weak section.

Irrigation is one of the important factors of production in modern agriculture. There is a significant difference between per hectare yield of irrigated and unirrigated crops. Difference in yield creates difference in incomes which results in inequality in income distribution.[2] The farm population from unirrigated area lives in extreme poverty compared to farm population from irrigated area. In 1978, only 28 per cent of the gross sown area in India was irrigated. Under such circumstances, it would be worthwhile to identify the percentage of population which lives below the povertyline in the irrigated and unirrigated area, so that Government can undertake certain programmes to help these weaker sections.

Methodology

With the above mentioned objectives in mind a study was undertaken in Union Territory of Delhi. Two villages were selected, one was an irrigated village having 91.41 per cent area under irrigation and another village in which area under irrigation was negligible. Name of the irrigated village is Chhattrapur and that of unirrigated village is Jonapur. These villages are situated in Mehrauli block near Delhi. Data was collected during April.—May 1973 by survery method. Comprehensive schedules were prepared for this purpose. Data was collected for agricultural year 1972-73. Two random samples were taken, one from Chhattrapur and another from Jonapur. Lorenz curve and Gini-ratio techniques were used for this analysis. For defining poverty-line least cost combinations of

be considered along with the degree of inequality.

6. Extension activities should be increased

structures does not remain in good condition over a long period of time.

The above storage stuctures can be divided in two following categories :

1. Under ground storage structures;
2. Above ground storage structure;
   (a) Made of kachha or pucca bricks, burnt or unburnt clay;
   (b) Made of wood, bamboo, or other plant materials.

Under Ground Storage Structures

These storage structures are being used mostly in U.P., Bihar, M.P., Maharashtra and A.P. for storing Wheat, Paddy and Jowar in bulk. They consist of simple pits of different sizes dug out underground. Mat or straw lining is put between the grain and the walls, floor, and roof to avoid moisture. Though the cost of the structure is very low, i.e., 2/3 of the above ground type, the grain stored deteriorates in quality and quantity due to increase in moisture which provides a favourable environment for insects and micro-organisms to flourish. The grain stored cannot be used as seed due to low viability and germination percentage. Sometimes the moisture increases sharply due to the rise of sub-soil water and the total grain is damaged. The odour of grain is also not good and thereby it fetches a low price in the market.

Above Ground Storage Structures

Grain in above ground structures can be held either in bulk or in bags. The choice between bulk or bag depends on the type of produce, duration of storage, value of produce, climate, transport system, cost and availability of labour and bags etc.

The indigenous above-ground storage structure, are not moisture proof, rodent proof and lack air tightness which is absolutely necessary for fumigation. The other type of above ground structures, made of plant material, are very porous, and fail to meet the requirement of scientific storage. The main cause of spoilage in these structures is moisture, sub-soil water, rain, animals, thefts, insects, rats etc.

In general the comparison of bulk and bags is as follows :

Sl. No.	Bag	Bulk
1.	Segregation of grain is possible	Not possible
2.	Partly mechanizable	Can be mechanized
3.	Low capital cost	High capital cost
4.	Considerable spillage	Little spillage
5.	High operating cost	Low operating cost
6.	High rodent loss	No rodent loss
7.	Fumigation is not very effective, reinfestation occurs	Fumigation is effective and protection against reinfestation

Proposed Modifications for the Improvement of Existing Village Level Structures

I. Under-ground storage facility

With a view to avoid damage to stored food grain caused by seepage of water through wall, floor and roof of the structure, a moisture barrier, i.e. 1000 gauge polythene should be sandwiched between the earthen wall of dug out pit and masonary wall, floor and roof.

The wall of this structure can be made using bamboo and cement, bamboo reinforced concrete, pucca bricks, or burnt clay rings.

II. Bag storage structure

Bag storage may not be practiced because of high operating cost, susceptability to rapid damage by insects, moisture, pilferage, rodents, etc. If there is no alternative, dunnage should be used to avoid moisture from the floor. For insect and rat control, cover fumigation and rodent proofing platforms should be used.

III Bamboo structures

These structures have been in use in most of the states of our country but have not been

scientifically designed. They can be improved by using the following :

(i) Bamboo cement; (ii) Bamboo reinforced concrete; (iii) Bamboo bin plasterd with linseed oil and ash.

The cost and expected life of these structures have been shown in table I. The storage studies conducted by the authors on the above mentioned bins have indicated that these bins are suitable for storage of wheat and paddy even in the hot and humid climate of West Bengal where there is acute problem of storage.

Table 1

Capacity, expected life and cost of Bamboo storage structures

Sl. No.	Type	Capacity Kgs.	Cost Rs.	Expected life yrs.	Cost per quintal per year Rs.
1.	Bamboo Reinforced	325	115/-	30	1.18
2.	Bamboo Cement	200	26/-	10	1.30
3.	Linseed Oil & Ash	200	56/-	15	1.86

IV. Structure made of mud, kachha bricks

The losses caused by rodents and moisture increase are the two major problems which have been observed in these structures. For rodent loss, either the structure should be built on a raised platform with inverted metallic cones or broken glass pieces, iron scrap etc. should be put in mud mortar under a final smooth layer of plaster at the outer wall of the structure. To prevent losses due to moisture, moisture proof materials should be used.

V. Structures made of pucca bricks

The existing pucca structures having a centrally located window/gate for loading and unloading the grains can be made reasonably air tight by providing suitable inlets and outlets and moisture barriers for the floor and in the walls exposed to rain. This work has been carried out at Indian Grain Storage Institute, Ludhiana.

VI. R.C.C. rings

In addition to the improvement of existing storage structures, there is a need to introduce modern storage structures at village level. An R.C.C. ring bin has been designed and constructed by the Indian Grain Storage Institute, Ludhiana and found very satisfactory in rural areas for capacities of 5 to 10 quintals. These are however suitable only for grains having safe moisture level of storage.

VII. R. B. bins

These are indoor storage bins, developed by Indian Grain Storage Institute, Ludhiana for the storage of food grains at safe m.c. level. These are cheap, better thermally insulated, and durable in comparison to metal bins.

VIII. Metal bins

These bins have been designed, developed and tested by the Indian Grain Storage Research Institute for indoor and outdoor storage of food grains. The grain can be safely stored and protected against insects and pests.

IX. Structure made from plant materials

The improvement of structures made from paddy straw and wheat straw are known as Puri and Kup respectively. These cannot be made airtight within reasonable cost. Only damage due to rodents and moisture through the floor may be avoided by providing moisture and rodent proof base of brick masonary or raised wooden legs with metal cone inverted at 45° embedded in the cement concrete floor. The structure provides ventilation to the food grains stored in it except in adverse weather.

Present Problem of Handling Grains

In our country more than 90% farmers harvest the crop manually and thresh it, either with threshers or bullock treading. Due to kachha threshing floors, more than 2% grain is wasted including the quantity eaten by birds.

The grain is transferred from the bullock carts or tractor-trailer manually and stored for seed, self consumption, cattle feed, etc. without any processing of food grains. Such processing

is very important for the purpose of maintaining the quality and quantity of seed and feed. The mature grain, chaff, straw, light grains, etc. should be removed and brought to a safe level for proper storage as well as for meeting the market standards to get higher price. With a view to improve the handling of food grain at village level the following programme is proposed:

Co-operative Owned Machinery and Equipment

In this system a group of cooperative societies should buy the machinery and charge for the work done either on the basis of output or at hourly rate.

The following machinery would be necessary to handle the grain :

	Approximate Cost
i) Threshers	Rs. 25,000.00
ii) Moisture meter and samplers	Rs. 3,000.00
iii) Dockage tester	Rs. 5,000.00
iv) Cleaners/graders	Rs. 15,000.00
v) Weigh bridge (5T)	Rs. 5,000.00
vi) Drier	Rs. 10,000.00
vii) Elevators, augers and belt conveyors	Rs. 25,000.00
viii) Grain treating machine and stitching machine for seed package	Rs. 5,000.00
ix) Grain bins	Rs. 40,000.00
x) Insecticides, fumigants	Rs. 5,000.00
xi) Quality control lab.	Rs. 15,000.00
xii) Buildings (100' x 40' Shed) (33m x 13m)	Rs. 1,20,000.00
Total	Rs. 2,73,000.00

The above machinery and equipment should be kept in a shed of 33m x13m, where all operations can run. This system will cut the expenditure on transportation of seed and feed. The seed is also expensive if individual farmers buy from the market through National Seed Corporation and Trai Development Corporation Keeping this in view, it would be definitely economical and feasible to store the seed at cooperative or community level and preserve and use it at the time of need.

REFERENCES

1. Giriesh G. K. *et al Losses in Food Grains, Post-Harvest Technology for cereals* 1972 pp. 199-207.
2. Agarwal N. S. *Design of storage structures, Post-harvest Technology for cereals* 1972 pp. 153-158.
3. Tripathi S. K. *Traditional Farm Storage facilities and their improved technology.* Paper presented at XVI Annual Convention of ISAE, APS/ 45, 1978.
4. Tripathi S. K. *Design Development Testing and Transfer of Technology of R.C.C. bin, R. B. bin and metal bins and Rural areas.* Paper presented at XVI Annual Convention of ISAE, APS/42, 1978.
5. Tripathi S. K. *Grain handling and marketing in Khanna Mandie* (Punjab). Paper presented in XVI Annual Convention of ISAE, APS/43, 1978.
6. Tripathi S. K. Maheshwari R. C., Ojha, T. P. and Gupta A. P. *Development and storage studies on Rural storage made from Bamboo and Bamboo composites,* Paper presented in XVI Annual Convention ISAE, APS/41. 1978.

CORRECTION

In the April-June '81 issue of Productivity material relating to Fig. 1 on page 77 in the article "Comparitive Cost Analysis of some Rice Polishers" may be read as 2, 3, 1, 4, instead of 1, 2, 3, 4.

Productivity
1981, XXII, 2. 87-91

The Tile Industry : Analysis of a Survey

BALJIT SINGH
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A survey was conducted by the National Productivity Council in 1978-79, wherein a number of tile units of Kerala were covered to assess and pinpoint areas for productivity improvement. It identified the urgent need for improved production techniques and marketing strategies.

The first tile factory in India was started in 1865 at Mangalore under the patronage of a German Basel Mission, headed by George Plebst. Availability of quality clay, firewood and presence of natural humid climate so necessary for drying of green tiles without cracking or warping contributed to the growth & rapid expansion of this industry. Today it has become a major industry of Kerala and Karnataka. In fact, Kerala is the home of tile industry in India. Out of nearly 500 units in the country, nearly 300 are situated in Kerala. The districtwise distribution in Kerala is given below :

Districtwise Distribution of Units

1.	Cannanore	25
2.	Calicut	20
3.	Malappuram	20
4.	Palghat	15
5.	Trichur	150
6.	Ernakulam	25
7.	Kottayam	5
8.	Alleppey	3
9.	Quilon	35
10.	Trivandrum	2
		300

While the tile industry has seen great expansion and provided much employment, it is today facing a state of uncertainty. The industry had been enjoying a good market for many years. The larger units were exporting their tiles to other countries while the smaller ones catered to the home demand. Thus, the industry hardly faced any competition. The position changed as foreign countries started their own manufacturing units causing the bigger Indian units to offload their production to the domestic market itself. With increase in quality consciousness and due to factors like brand image, the Indian Market did not fully accept the product of the non-mechanised smaller units despite the lower prices. Thus, the industry as a whole is now passing through a precarious situation wherein the markets have considerably dwindled, the manufacturing costs have gone up, firewood has become not only costly but also scarce, freight charges have considerably increased and good quality clay itself is not abundantly available. Not only has the industry to cope with dwindling resources, it has to meet a far more important challenge of finding a market for what is produced.

A survey was made by the National Productivity Council in 1978-79, wherein a number of tile units of Kerala were covered to assess and pin point areas which could be taken up for improving the productivity of the Tile Industry as a whole. A few of the observations made are highlighted herein.

Clay Selection and Storage

Clay is the only raw material used in the manufacture of tiles and is obtained from paddy fields about 3 to 4 feet underground. This clay is dug out manually and transported by means of trucks or boats to the factory site. Great importance needs to be given to the matter of choice of clay. Clay is generally procured through contractors or from one's own paddy field. The clay is procured before the using season and left in the yard for weathering. Stocks of clay vary from unit to unit but it has been as high as for 2 years consumption. It would be worth-while to mention that one year's stocks of clay for a unit manufacturing 10,000 tiles, comes to a working capital blockage of Rs. 1,80,000 considering clay to cost Rs. 60/100 cu. ft. The interest lost in one year alone would be Rs. 30,000 (at 18%).

Similar figures for other levels of production are given below to indicate the extent of blockage of capital and the loss of interest thereon.

Daily production (Tiles)	Quantity cu. ft.	Capital blocked in Rs.	Interest lost@18% Rs.
3,000	300	54,000	9,720
15,000	1,500	2,70,000	48,600
25,000	2,500	4,50,000	81,000

There is an opinion that clay Ageing is an absolute necessity. It is true that with ageing the reaction of H_2O with atmosphere CO_2 leads to the formation of Carbonic-Acid which acts as a plastic bond and thereby increases plasticity to some extent. While scope exists for further research on clay constituents, ageing etc., it may be pointed out that there are some units which have used clay directly without ageing and the results have given good quality tiles. It is only during the rainy season that one should have stocks to keep the production going. In fact, 4 weeks stocks of clay are sufficient considering Ageing etc.

The sand content and the grain size of sand are important factors which govern the ultimate quality of tiles. With more sand content, water absorption is more and shrinkage is less. Brittleness is also increased. On the other hand, if sand content is too low, shrinkage will increase and the clay will be more plastic. The optimum level of sand content is about 20%. The de-airing pugmill can do well with clays having 20-22% of sand while the ordinary pugmill works fairly well with about 15-18% sand. Sand testing is one aspect which is more or less neglected. Sand content is easily tested by placing 5 kg. of sample clay in a bucket full of water and stirring the mixture. This process of mixing and stirring is done at least 3 to 4 times to ensure thorough mixing. Sand settles at the bottom and is dried in the kiln top for about 10-15 minutes before weighing. The weighed sand is analysed through sieves of 10,20,40,60 and passing 60 sieves. The sieve analysis is done to find the nature of the sand like fine or coarse etc. Finer the sand, finer the finish.

Slab Preparation

Properly proportioned clay should be sent through the following successive stages before drying of slabs :

(1) Coarse Grinding

(2) Double Shaft Mixing

(3) High Speed Fine Grinding

(4) Pugmill/De-airing Pugmill

(5) Pressing

The practice of passing clay through a double shaft mixer and then through the coarse grinder spoils the blades of double shaft mixer and much maintenance work has to be done.

In some cases the clay is de-aired and then pugged. De-airing pugmill breaks the clay mass into smaller particles and sucks out the air. With de-airing, the quality of the blocks is improved and the clay does not wrinkle or warp. Moreover de-aired blocks need not be kept for a day or two before being pressed. However, de-airing is essential only where clay is not very plastic. Highly plastic clays do not always respond well to de-airing. Another observation worth mentioning is that the de-airing pressure is often not attained and the blocks get warped and wrinkled.

Storing of de-aired blocks is a practice which spoils the quality of the tiles through loss of the deairing affect. However, storing after pugging is useful.

While pressing, oil is put on the mould and also on the slabs. At times excess oil is put and this prolongs the slab drying time. The manual presses in some factories can give only 3000 tiles/ 8 hours, while the Power Press, having 5 moulds can give 7000 tiles/ 8 hours. The trimming operation could be done by the power press itself. Presently trimming is done separately on a revolving table.

After trimming, the tiles have to be conveyed to the frames. A lot of scope exists for improved handling of these tiles. In fact the rejection of green tiles are as high as 15%. Most of these rejections are due to improper handling.

Thus, even if 10% of the tiles are reprocessed, it means :

Production	Rejections	Extra hrs. required for pressing
If 8000/day	800 tiles/day	Nearly 1 hr.
If 25000/day	2,500 tiles/day	3 hrs.

Drying

The drying time for green tiles varies from 5 days to 8 days during the dry season and is about 10-15 days during the rainy season. Nearly all the units rely on atmospheric drying.

Drying itself takes place in stages. In the first stage, since the moisture content is very high, the tiles should not be exposed to sudden heat. Hence the tiles after pressing should be kept in uniform atmospheric conditions. The second stage involves exposing the tiles to slightly hot conditions and in the final stages to hotter conditions (105-110°C).

Some units achieve the above by placing the tiles for about 4 days in the area exposed to fresh air and then transferring them to the space above the kilns for the next 4 days. This, of course, means an additional handling, but it gives good drying. The whole drying process is in itself cumbersome and requires lot of storage space, pallets and inprocess inventory. The cost of pallets alone would be :

Cost of Pallets

Upto 8,000 tiles/day	8 x 8,000 64,000 x 1.40* = Rs. 89,600
Upto 25,000 tiles/day	8 x 25,000 x 1.40 = Rs. 280,000

*Considering 1 pallet to cost Rs. 1.40

The amount of capital blocked by this drying will be :

about 3.00 lacs. The conversion to the Hoffman continuous kiln is not difficult. It would require

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Productivity
1981, XXII, 2, 93-97

Management Methods Can Increase Productivity

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The results attained in a department should be evaluated both for the aggregate of its activities over a period of time and for each project & service performed. This evaluation should be used periodically as a basis for deciding if the activities should be expanded, remain stable, or be reduced.

Ordinarily there are many possible solutions to management and technological problems in the daily operational working environment. Very rarely in the procedure of working out a solution to improve an operation or a work process does the manager find it possible or practical to conceive all possible alternative solutions. The possibility of arriving at the best solution is difficult for the working manager in today's industrial and business environment.

Almost invariably the manager or supervisor finds it impossible to obtain a perfect or even comprehensive evaluation of alternatives to the problem. Normally there are many variables involved and generally only a relatively short period of time in which to evaluate solutions, so that many important variables bearing on the decision must be ignored or treated superficially. Furthermore, in many cases, the manager is unable to measure important variables bearing on the decision concerning the operational aspects of the operation.

Finally, errors are made in measurement and prediction of the performance of various systems. Thus, much of the final evaluation of alternatives is of necessity left to judgement.

In much of the work, a manager must rely heavily on creative ability in generalizing and formulating solutions to problems. Certainly, he or she has a given body of knowledge comprised of principles, accepted common practices, knowledge from experiences with previous problems,

etc., but all this is only of limited assistance in view of the *uniqueness* of most problems encountered daily. Because problems differ in so many ways, significant portions of the solution format are the result of the manager's own inventiveness. Therefore, managers must rely on their own ingenuity to produce ideas in those many situations in which solutions derived from experience, existing principles, or previous practice do not exist. Creativeness is a vital asset, an indispensable attribute in managers, supervisors or administrators who improve the operation in order to increase productivity.

Manner in which Problems are Viewed

Problems will never be handed to one in a nice orderly format; rather, they usually occur with a situation in a very turbulent state, and the manager must proceed from there. The extent to which judgment must be exercised in dealing with every day business, human, or technical problems is sometimes disturbing and difficult to accept at some stages of managerial development. Unfortunately or fortunately, judgment plays a major role in the decision-making process.

Considerable judgment is usually required in deciding on the best way to approach a particular problem; the best procedure, technique and manner in which the problem is quantified will follow. Such matters are seldom precise; in fact, they are often the subject of considerable disagreement among practitioners. No procedure, practice, or policy used in the business, industrial or practicing world is without flaw and disadvantages. The ways of solving real world problems and the solutions thereby produced have variations. Because solutions must be attained in practice, the manager makes decisions on the best information available regardless of imperfection in this information.

There are numerous trends in the industrial and professional scene with which the manager should be familiar, Failure to react early and effectively, can be very costly. Typical of anticipated trends in and affecting productivity are the following.

1. Continued and probably accelerated rate of conversion to mechanization.

a. Some consequences of this trend are :

— indirect labour will become an increasing percentage of the total labour force.

— man will perform fewer direct production tasks, but the role he does play as a monitor, servicer, or emergency link in the system will become increasingly critical to speed and effectiveness of action.

— the work of the human being will be less demanding physically.

— the work of the human being will demand more technical skill and training because of man's enlarged role as a decision maker (repairman, adjuster, planner, etc.) and because of increased complexity of his task. Thus investment in the employee will be greater.

b. These changes will affect the operational phase in a number of ways.

For example :

— since most indirect labor is much more variable than direct labor, both in content and in time, the need for analysis and measurement techniques different from those conventionally used on repetitive operations will be much more pressing.

— motivation of the operator's vigilance will become more of a problem, whereas motivation of physical exertion will become less important.

— as the machine assumes control of the rate of processing, prediction of performance time will become less of a problem.

— the prediction and control of learning time will become of more importance as the investment in the employee increases.

— there will be increased need for

the body of knowledge presently characterized as "human engineering".

— the process of troubleshooting will receive increasing attention, as breakdowns of equipment become more likely, more difficult to diagnose and more expensive.

2. Increased interest in the human element of the productive process.

a. Some consequences of this trend are :

— increased attention will be given to proper design of the task and equipment associated with it.

— there will be a greater interest in the currently unquantifiable cost of work, such as fatigue, monotony, effort, etc.

— there will be greater interest in nonfinancial incentives.

b. These changes will probably affect methods design in the following ways :

— there will be an increased demand for objective work design principles.

— there will be an increased demand for objective methods of measuring fatigue, monotony and effort.

— wage incentive plans as currently known will become less popular.

Evaluation and Improvement in Work Methods

The results actually attained in a department's undertaking should be evaluated both for the aggregate of its activities over a period of time and for each project and service performed. This evaluation is necessary for justification of the current level of operation of the department. The follow-up evaluation of the outcome of individual activities is essential if improvement in performance of the department is desired.

Knowledge of the results being achieved should be used periodically as a basis for deciding if the activities of the department should be expanded, remain stable, or be reduced. To illustrate the type of improved management methods, in order to increase productivity, the following checklist of questions is presented. To this sample list, the experienced manager could add numerous other questions.

1. What percentage of the workday is actually devoted to *profitable endeavor?*

2. With reference to personnel :

a. what about the capability of each staff member with respect to technical ability, creativeness, and ability to effectively work with others in the organization?

b. is each adequately trained and indoctrinated ?

c. what about the enthusiasm of each ?

d. what is the estimated return on the company's investment in each staff member ?

3. With respect to *methodology* :

a. is the department's general methodology in accord with current "enlightened" theory and practice ?

b. is the methodology of the department being developed to meet anticipated trends in the business and in industry ?

c. what is the typical manner of approach to a design problem ? Is an intelligent problem-solving approach used ? Is sufficient time devoted to problem formulation and analysis ? Is too much time spent instead in analyzing and scrutinizing existing methods ?

d. is adequate use being made of the knowledge relatively recently made available by the field of experimental psychology, under the popular heading of human engineering data ?

e. is adequate use being made of the

full range of techniques available to the methods engineer, especially the more recent ones such as predetermined motion times, work sampling, time-lapse photography, tape recordings for on-the-job instruction, and a number of others ?

f. is the department doing an effective job of implementing (selling and installing) its proposals ?

4. With respect to *programming* :

a. are the projects selected in accord with overall objectives ?

b. does the distribution of resources between methods design and work measurement appear optimum ? Between initial design and redesign ?

c. is an adequate percentage of the department's efforts being directed to indirect labor ?

d. is the amount of time devoted by professional persons to semitechnical and nontechnical tasks kept to a minimum ?

5. With respect to relations with remainder of the *organization* ;

a. has the department been successful in retaining management's confidence and support ?

b. is there a harmonious relationship between the department and other technical specialities ? Or have opposing "empires" arisen, manifestations of certain personal ambitions of various managers ?

c. has the department been able to maintain a satisfactory relationship with shop supervisors ? With workers ? With organized labor ? What is the attitude of each towards the department and the individuals in it ? How much cooperation is received from them ?

d. does the department hold a position of positive leadership in the organization with respect to the matter of work methods ? Have its educational and promotional efforts been successful in arousing enthusiasm and active participation of the organization in the improvement of work methods ?

6. With respect to *evaluation itself* :

a. is a sincere attempt made to follow up on each undertaking of the department, in an effort to learn, to improve future performance ?

b. is a satisfactory effort made to periodically reappraise the function of this specialty ?

c. is a periodic attempt made to evaluate the department's scale of operation, to determine if expansion or contraction is desirable ?

d. is an attempt ever made to classify estimated benefits according to type of department endeavor, in an effort to determine the most profitable allocation of the department's resources ? For example, what is the relative "payoff" on efforts devoted to methods design as opposed to work measurement ? On attention devoted to direct labor as opposed to indirect labor ? On efforts devoted to improving methods in production department A as opposed to production department B ?

Knowledge of results of the individual project, of the results attained in different types of undertakings, and the results of the aggregate of the department's activities, should be put to effective use in correction and improvement of future performance. This applies to department function, level of activity, personnel, methodology, programming, organizational relations, and evaluation.

The completeness and effectiveness with which a manager or administrator in any organization obtains and benefits from knowledge of the results of Evaluation and Improvement Study is an excellent index of his or her management ability.

REFERENCES

Aquilano, Nicholas J. A. Physiological Evaluation of Time Standards for Strenuous Work as Set by Stopwatch Time Study and Two predetermined Motion-Time Data Systems. *Journal of Industrial Engineering*, Vol. 19, No. 9, September 1968.

Barnes, Ralph M. *Motion and Time Study : Design and Measurement of work.* 6th ed. New York : John Wiley & Sons, 1968.

Dunn, J. D., and F. M. Rachel *Wage and Salary Administration.* New York : McGraw-Hill, 1971.

Fitzgerald, Thomas H. Why Motivation Theory Doesn't Work, *Harvard Business Review*, July-August 1971.

Geare, A. J. Productivity from Scanlon-type Plans. *Academy of Management Review*, Vol. 1, No. 3, July 1976.

Hamilton, Bernard J., and Chase, Richard B. A. Work Physiology Study of the Relative Effects of Pace and Weight in a Carton Handling Task, *AIIE Transactions*, Vol. 1, No. 2, June 1969.

Herzberg, F., Mausner, B., and Snyderman, B. B. *The Motivation to Work.* 2nd ed. New York : John Wiley & Sons, 1959.

Mundel, Marven E. *Motion and Time Study.* Englewood Cliffs, NJ : Prentice-Hall, 1960.

Niebel, Benjamin W. *Motion and Time Study*, 6th ed. Homewood, IL : Richard D. Irwin, Inc. 1976.

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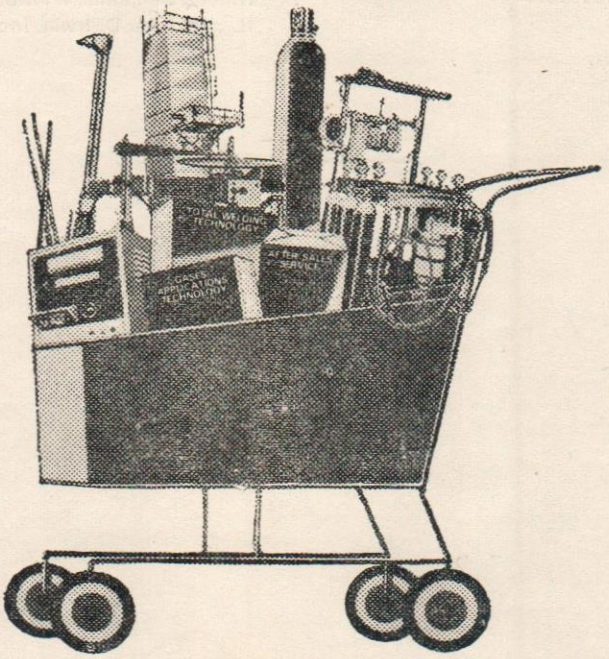

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1. GENERAL

A. BOOKS

American Management Association : *Meeting the productivity challenge.* New York : A.M.A., 1960, 102 p.

Asian Productivity Organization : *Fourth workshop meeting of Directors of productivity Centres.* Japan, A.P.O., 1964, 153 p.

———— : *Industrial Relations and Productivity in Japan No. 26,* Tokyo : A.P.O., 1971. 108 p.

———— : *Study report on productivity drive program planning and coordination.* Tokyo : Asian Productivity Organization 1962. 79 p.

Backman, Jules (Ed.) : *Labour Technology and Productivity in the seventies.* New York : New York Uni. Press, 1974. 144 p.

Beesley, Michael : *Productivity and amenity : Achieving a social balance.* London : Groom Helm, 1974. 135 p.

Bergson Abram : *Productivity and the social system : the USSR and the West.* Massachusetts : Harvard University Press, 1978, 256 p.

Bhattasali B. N. & Bhattasali G. Miss : *Productivity and Economic Development.* Tokyo : A.P.O., 1972, 121 p.

Bombay Productivity Council : *Seminar on higher productivity through building insulation.* Bombay : BPC, 1967, 78 p.

Bradt A. Gordon : *Five keys to Productivity and profits.* New York : Parker Publishing Co., 1973, 215 p.

British Productivity Council : *Better ways—nineteen parts to higher productivity.* London : BPC, 1959, 97 p.

———*Communications in Industry,* London : BPC, 1960, 16 p.

———*Why productivity ?* London : BPC, 1954, 16 p.

Brown, M : *On theory and measurement of technological change.* Cambridge : University Press, 1966.

Butterworth J : *Productivity Now.* Oxford ; Pergamon, 1968, 160 p.

Cummings Thomas G : & Molloy Edmond S : *Improving Productivity and the quality of work life.* New York : Praeger Publishers, 1977, 305, p.

Dattar B.N. (Ed) : *Productivity agreements, Workers motivation and sharing the gains of productivity.* Tokyo : APO, 1976, 114 p.

Delhi Productivity Council : *National convention on productivity.* Delhi : Delhi Productivity Council, 1976, 102 p.

Denison, E.F. : *Why growth rates differ : postwar experience in nine western countries.* Washington : Brookings institution, 1967.

Dunlop John T. & Diatchenko V.P. : *Labour Productivity.* New York : McGraw-Hill, 1964, 409 p.

Durgesh Chandra : *Dynamics of Productivity.* New Delhi : South Asian Publisher, 1980, 258 p.

Edwards, Ronald, & Roberts, RDA : *Status, Productivity and Pay : A Major Experiment.* London : Macmillan, 1971, 456 p.

Fabricant, Solomon : *A Primer on Productivity*. New York : Random House, 1969, 206 p.

Fair, Ray C : *The Short-Run Demand for Workers and Hours*. Amsterdam : North-Holland, 1969, 225 p.

Fallon, Carlos : *Value analysis to improve productivity*, New York; Wiley, 1971, 359 p.

Faraday J. E. : *The Management of Productivity*. London; BIM, 1971, 81 p.

Felner, W : *Appraisal of the Capital-Saving & Labour saving Character of Innovations, The Theory of Capital*. Macmillan : London, 1963.

Flanders, Allan ; *The Fawley Productivity Agreements : A Case Study of Management and Collective Bargaining*. Victoria, Australia : Faber & Faber, 1968, 360 p.

Fuchs, Victor R (Ed.) : *Production and Productivity in the Service Industries. Studies in Income and Wealth, Vol. 34, by the Conference on Research in Income and Wealth*, New York : Columbia University Press, 1969, 395 p.

Gaalhon, AL : *Economic Productivity in Israel*. New York : Praiger 1971.

Gellerman Saul W : *Motivation and Productivity*. Bombay : D.B. Taraporevala, 1968, 304 p.

Griliches, Z : *Notes on the Measurement of Price and Quality Changes in Models of Income Determination*. Princeton University Press : NBER, 1964, 381-404 p.

Harlow Chris : *Innovation and Productivity under nationalisation, First-thirty years*. London : George Allen & Unwin, 1977, 256 p.

Hartman, Paul T : *Collective bargaining and productivity. The Long-Shore Mechanization Agreement*. Los Angeles : University of California Press, 1969, 307 p.

Heaton Herbert : *Productivity in service organizations : Organizing for people*. New York : Mc Graw-Hill, 1977, 233 p.

Hornbruch Frederick W : *Raising Productivity : Ten case histories and their lessons*. New York, : Mc Graw-Hill, 1977, 339 p.

Hinrichs John R : *Practical Management for productivity*. New York : Von Nostrand Reinhold Co., 1978, 192 p.

International Labour Office : *Measuring Labour Productivity*. Geneva : ILO, 1969, 172 p.

——————— *Methods of labour productivity statistics*. Geneva: ILO, 1951, 136 p.

Kendrick John W. : *Productivity trends in the United States*. Princeton; Princeton University Press, 1961, 630 p.

——————— *Understanding Productivity : an introduction to dynamics of productivity change*. Baltimore: John Hopkins University Press, 1977, 141 p,

Lie Kwan H : *Productivity and Economic Growth*. Tokyo ; APO, 1971, 214 p.

Mali Paul : *Improving total productivity*. New York : John Wiley, 1978, 409 p.

Melman Seymour : *Decision-making and Productivity*. New York: John Wiley, 1958, 260 p.

Nadkarni GA : *Performance Productivity and profit improvement ; a consultants approach*. Bombay : G. A. Nandkarni, 1976, 793 p.

Nakayama Ichiro : *An Introduction to Productivity*. Tokyo : Japan Productivity Centre, 1963, 50 p.

National Economic Development Council : *Productivity prices and Incomes : A general review*. London : HMSO, 1967, 46 p.

National Productivity Council : *Impact of productivity : A collection of cases*. New Delhi : National Productivity Council, 1964, 70 p.

——————— *Seminar on (1) Co-operation for higher productivity (2) Sharing the gains of productivity*. New Delhi : NPC, 23 p.

——————— *Sharing the gains of productivity* : New Delhi : NPC, 1967, 46 p.

National Institute for Training in Industrial Engineering : *Report of a Research Project on Wage Productivity Correllation*. Bombay; NITIE, 1971.

Nayar, G.K. & Marandu, DM : *Meaurement of Productivity*. Dar-es-Salaam; National Institute for Productivity, 1969.

Nelson RR : *Aggregative production functions and Economic Growth policy in the Theory and Empirical Analysis of Production*. NBER, 1967.

North Dt. B & Buckingham G. L. : *Productivity agreements and wages systems*. London : Gower Press, 1969, 262 p.

Numerical control society, : *Opening door to Productivity and profit proceedings*. Anaheim : NCS, 1971, 486 p.

Organisation for European Economic Co-Operation : *Inter-firm comparison : an incentive to productivity*. Paris : OEEC, 1957, 352 p.

——————— *Productivity and Economic Planning*, Paris : OECD, 1970, 323 p.

Pack, Howard : *Structural Change and Economic Policy in Israel*. London : Yale University Press, 1971

Paige, Deborah & Bombach, Gottfried : *A Comparison of National output and Productivity of the United Kingdom and the United States*. Paris : OECD, 1959.

Pennathur, K : *About Productivity*. Delhi : National Productivity Council, 1966, 24 p.

———————— *Productivity is for you too.* New Delhi : National Productivity Council, 1966, 130 p.

Productivity Promotion Council of Australia : *Productivity : The way ahead, Book 1 - Goals and Barriers.* Australia : PPCA, 1972, 88 p.

———————— *Productivity : The way ahead. Book-2. Human resources,* Australia : PPCA, 1972, 88 p.

———————— *Productivity : the way ahead, Book 3-Management* Australia : PPCA, 1972, 81 p.

———————— *Productivity : the way ahead Book 4 : Distribution and Technology.* Australia : PPCA, 1972, 90 p.

Ramachandran N & others : *Role of Productivity in Asian Economic Growth.* Tokyo : A.P.O., 1970, 186 p.

Ross Joel E : *Managing Productivity.* Reston : Reston Publishing Co., 1977, 191 p.

Salter W.E.G. : *Productivity and technical change.* London : Cambridge University Press, 1960, 198 p.

———————— *Productivity and Technical change with an Addendum by Reddaway W. B.* Cambridge : Cambridge University Press, 1969, 220 p.

Saxena A. N. : *Horizons to Productivity.* Delhi : National Productivity Council.

Shapiro Eli & White W. L. (Eds.) : *Capital for Productivity and jobs.* New Jersey : Prentice Hall, 1977, 203 p.

Shaw John C. : *The Quality - Productivity Connection in Service sector management.* New York : Van Nostrand Reinhold Co., 1978, 143 p.

Shrivastava O. S. : *Economics of Wages, Productivity, and Employment.* Gwalior : Kailash Pustak Sadan, 1968. 257 p.

Smith, Ian G : *The Measurement of Productivity : A system approach in the context of productivity agreement.* London : Gower Press, 1973.

Staely John D. & Delloff Irving A : *Improving Individual productivity.* New York : A.M.A., 1963, 207 p.

Stein, H. & Nark, J. A. *The meaning and measurement of productivity.* Washington : *Bureau of Labour Statistics,* 1971.

Steinervan D. : *Group process and productivity.* New York : Academic Press, 1972, 204 p.

Stettner, N : *Productivity Bargaining and Industrial Change* Oxford : Pergamon, 1969, 204 p.

Stigler G. : *Economic Problems in Measuring Changes in Productivity, Output, Input and Productivity Measurement.* Cambridge, Mass : Aarnard University Press, 1966.

Strong Earl P. : *Increasing office productivity A seven-step program.* New York : Mc Graw-Hill. 1962, 287 p.

Suri G. K. : *Productivity, wages, and Industrial relations.* New Delhi : Affiliated East-West Press, 1976, 144 p.

Sutermeister Robert A: *People and Productivity edn. 3* New York; Mc Graw-Hill, 1976, 475 p.

U. K. National Economic Development Office : *Productivity : a handbook of advisory services.* London : H.M.S.O. 1967, 123 p.

Wallis S. Allen : *Progress against inflation : Wages, Productivity and Prices.* New York : N.I.C.B., 1960, 67 p.

Zaleznik, A. : *Motivation, Productivity and satisfaction of workers.* Boston : Harvard Business School, 1965 442 p.

B. ARTICLES

Agarwal, S. C. : Productivity concept and measurement : meaning, techniques and methods. *Lok Udyog,* 7(1), 1973 13-18 pp.

———————— Productivity : A measure or a mirage. *Productivity,* 21(4), 1981, 457-480 p.

Aiyar, Swaminathan : The tragic down fall of Productivity. *Eastern Economist,* 74(22), 30 May 1980, 1070-71 pp.

Athreya, M B : Social Justice : A new dimension of productivity. *Economic Times,* 16 Aug. 1980, 5 p.

Baktha, R : Productivity agreement - case study. *Productivity,* 14(1), Sept. 1973, 73-105 p.

Basu, S. P, & Sinha, B. K. : Operational Research and Productivity. *9th Annual Convention of ORSI,* Dec. 3-5, 1976.

Beri, E. C. : Mechanization, employment pattern and productivity. *Indian Journal of Industrial Relation,* 11(4), 1976, 429-444 p.

Bhattasali, B. N. : Accelerating productivity actions in India : A few important areas. *Productivity,* 13(2), 1972, 163-168 p.

Bhutani, D. H. : Productivity measurement problems. *Economic Times,* January, 1971, 5p.

Bowles, S : Aggregation of labour inputs in the Economics of growth and planning. Experiments with a two level CES function : *Journal of Political Economy,* 78, Jan. 70, 68-71 p.

Chandra, Durgesh : Productivity dynamics. *Productivity,* 19(1), 1978, 45-60 p.

Dalvi G. R. : Productivity and economic growth. *Productivity,* 12(2), 1971, 173-174 p.

Das, Nagagopal : Sharing productivity gains : no formula found acceptable to labour. *Statesman,* 23 August, 1971, 6 p.

Dravid, V. V. : Our contribution to productivity. *Indian Workers.* 24(28-29), 3 May, 1976, 19-20 p.

Federalist (Pseudonym) : On measuring labour productivity. *Productivity,* 14(3), 1973, 245-48 p.

Fremont, E. G. Jr : Productivity bargaining that really is. *Personnel*, Jan.-Feb. 1972, 8-18 p.

Ghosh, B. N. : Disguised unemployment and zero marginal productivity labour—Some complications. *Productivity* 13(1), 1972, 49-53 p.

Ghosh P. P. : Inter-state differences in the productivity of labour in India. *Journal of Social and Economic Studies* 1(1), March 71, 151-63 p.

Goel, V. K. : Linking bonus to productivity ? *Productivity*, 17(3), 1976, 329-340 p.

Goldrar, Bishwanath : Total factor productivity and the price indices. *Productivity*, 15(1), 1975, 513-517 p.

Goyal, S K : Productivity movement in India—some misconceptions. *Productivity*, 14(3), 1973, 233-137 p.

Grant, N B : Analytical statement of factors influencing productivity. *Proceedings of the Seminar on Higher Productivity in Public Sector Production Enterprises*, Sept. 12-13, 1975, 141-142 p.

Groff, G K : Worker productivity—an integrated view. *Business Horizons*, April 1971, 78-86 p.

Gupta, R S : Models for sharing the gains of productivity. *Productivity*, 14(1), Supple, 1973, 38-40 p.

Gupta, Rajendra Prakash : Trade unions and productivity. *Indian Workers*, 28(45, 46), 18 Aug. 1980, 49-50 p.

Jacob, M M : Distribution of productivity gains. *Productivity*, 14(1), Suppl. 1973, 41-44 p.

James, Charles F : A case for productivity circles in India. *Productivity*, 15(4), 1975, 464-469 p.

Karim, B : For higher productivity. *Proceedings of the Seminar on Higher Productivity in Public Sector Production Enterprises*. Sept. 12-13, 1975, 207-218 p.

Khandelia, R P : Impact of management decisions on labour productivity. *Productivity*, 12(4), 1972, 539-543 p.

Korgaonker. M G : Productivity : A system approach. *Productivity*, 18(1), 1977, 13-24 p.

Kotia, D K : Measurement of capital productivity. *Productivity*, 19(2), 1978, 211-216 p.

Krishna, K L : Total Factor Productivity : Concept & Measurement. *Productivity*. 10(4). Jan.-March 1970, 701-705 p.

Lal, B B : A note on productivity and economic growth (with special reference to India). *Indian Journal of Economics*, 55(1), 1974, 139-40 p.

Law, Donald E : Measuring productivity, *Financial Executive*, Oct. 1972, 24-27 p.

Lynch, Philip : How to bargain for productivity, *Management Today*, May 1972, 117-128 p.

Madhavan, R : Productivity movement and management responsibility, *Productivity*, 14(3), 1973, 238-240 p.

Maini, S K : Raising the productivity and sharing its gains. *Productivity*, 14(1), Suppl. 1973, 29-37 p.

Meher, M R : Sharing productivity gains. *Productivity*, 12(4). 1972, 522-24 p.

Menon, S. C. S : Productivity agreement—A trade union point of view. *Productivity*, 14(1), Suppl. 1973, 45-56 p.

Mukherjee, S K & Singh, D : Management of productivity. *Proceedings of the Seminar on Higher Productivity in Public Sector Production Enterprises*, Sept. 12-13, 1975, 91-103 p.

Nadiri, M Ishaq : Some approaches to the theory and measurement of total factor productivity. A survey. *Journal of Economic Literature*, 8(4); December 1970, 1137-78 p.

Nair, N K : Contribution of fertilizer to food production in India—some estimates, *Productivity*, 17(1), 1976, 107-26 p.

Nanges, Narendra & Other : Productivity enlargement in jobbing and mixed quantity production by group technology. *Productivity*, 17(3), 1976, 427-444 p.

Pat, Ram : Labour Productivity in Different sectors of Indian Economy. *Khadi Gramodyog*, 17(8), 1971, 536-548 p.

Pillai, P N Krishna : Concept of productivity agreements, *Productivity*, 14(1), Suppl. 1973, 12-17 p.

Ramachandran, S N : Productivity Services : An integrated approach. *Proceedings of the Seminar on Higher Productivity in Public Sector Production Enterprises*, Sept. 12-13, 1975, 58-82 p.

Ramaswamy, S S : Some factors influencing productivity of Indian workers. *Productivity*, 13(4), 1972, 513-521 p.

Rangenkar, Sharu, S : Improving managerial productivity. *Productivity*, 17(1), 1976, 76-85 p.

Rosenbaun, L L : Morale & Productivity—consequences of group leadership style, stress and type of task. *Journal of Applied Psychology*, Aug. 1971, 343-348 p.

Rosow, Jerome H : Now is the time for productivity bargaining. *Harvard Business Review*, Jan-Feb., 1972, 78-89 p.

Sachindranath, KP : Pre-requistes for sharing the gains of productivity. *Productivity*, 14(1), Suppl 1973, 67-72 p.

Saran, G : An integrated productivity services function : work design approach. *Proceedings of the Seminar on Higher Productivity in Public Sector Production Enterprises*, Sept. 12-13, 1975, 104-115 p.

Saxena, A P : Measuring Productivity in Government. *Indian Journal of Public Administration*, 22(2), 1976, 196-207 p.

Savilan, Hasmak : Achieving higher productivity for prosperity, *Indian Worker*, 28(45, 46) 18 Aug. 1980, 61-63.

———————— Human relations : Key to productivity, *Indian Worker*, 28(26), 31 March 1980, 5+p.

Shanker, Tilak & Prahalad, C K : Productivity Measurement : A Case Study, *Indian Management*, 10(4), April, 1971, 3-9 p.

Smith, Ian G : Productivity agreements and productivity. An appraisal and a possible approach to productivity measurement at the plant/firm level. *Industrial Relations Journal*, Jan.-Mar. 1971, 63-82 p.

Stanislao, Joseph : Increase productivity through motivation. *Productivity*, 18(3), 1977, 321-330 p.

Stanislao, Joseph & Maurer, K G : Increase productivity with numerical control machine systems. *Productivity*, 18(1), 1977, 51-64 p.

Suri, G K & Chellapa, H V V : Wage-cost productivity and income policy, *Indian Journal of Industrial Relations*, 9(1), 1973, 69-82 p.

Venu, S : Technological innovation and Productivity. *Productivity*, 15(3), 1974, 369-373 p.

Vepa, Ram K : Appropriate technology for increased productivity, *Productivity*, 12(2), 1971, 208-21 p.

Verma, Promod : Inter-regional differentials in labour productivity. *Productivity*, 12(4). 1972, 532-538 p.

Verma, R P : Productivity bargaining : its growth and process. *Journal of Social & Economic Studies*, 7(1), March 1979, 90-100 p.

Warriar, S K : Annual bonus linked to production/productivity, *Productivity* 18(1), 1978, 1-12 p.

————: Rationale of Productivity agreements. *Productivity*, 14(1), Supp. 1973, 18-28 p.

Watts, Gambhir : Productivity and distribution. A critical approach, *Management Accountant*, 15(11), Nov. 1980, 465+p.

Zudak, L S : Productivity, labour, demand and cost in a continuous production facility. *Journal of Industrial Economics*, Jul. 1970, 255-274 p.

2. AGRICULTURE

A. BOOKS

Abraham, T P : *Output Responses to Inputs and Yardsticks of Production in Agriculture. Seminar on Indian Agriculture Problems and Prospects.* Delhi : Agricultural Economic Research Centre, 1966.

Baldev Singh : *Capital Formation in the Agricultural Sector in Haryana.* University of Kurukshetra, 1972.

Bardhan P K : *Technological Change and Distribution of Gains in Indian Agriculture.* Delhi : Institute of Economic Growth, 1975.

Brown D D : *Agriculture Development in India's Districts.* Cambridge : Harvard University Press. 1971.

Chaudhri, D P : *Education and agricultural productivity in India.* A thesis submitted to University of Delhi, 1968.

Dharam Narayan : *The Impact of Price Movement of Area under Selected Crops in India, 1900-1939,* Cambridge University Press, 1965.

Easter, K W : *Regions for Indian Agriculture Planning and Management*, Ford Foundation (Memo), 1972.

Evenson, R E : *Labour in the Indian Agriculture Sector.* New Haven; Yale University (Memo), 1972.

Evenson, R E & Jha D : "The Contribution of the Agricultural Research System to Agricultural Production in India." Indian Journal of Agricultural Economics, Dec. 1973.

Mukhopadhyay, S K : *Sources of variation in agricultural productivity,* Delhi; Macmillan, 1976.

B. ARTICLES

A.I.M.O. The Impact of agricultural production on economic growth and development. Part 1, *Agriculture and Agro Industries Journal*, 7(10), Oct. 1974, 31-42 p.

———————— The impact of agricultural productivity on the Economic growth and development. Part II, *Agriculture and Agro-Industries Journal*, 7(11), Nov. 1974, 29-33 p.

———————— The impact of agricultural productivity on the Economic growth and development. Part III, *Agriculture and Agro-Industries Journal*, 7(12), Dec. 1974, 13-19 p.

Bardhan P K : Size, Productivity and Returns to Scale : An Analysis of Farm Level Data in Indian Agriculture. *Journal of Political Economy*, November-December 1973.

Bhardawaj, Krishna : Notes on farm size and productivity, *Economic & Political Weekly*, 9(13), 1974, 11-24 p.

Bhardwaj, K R & Bharadwaj R : An Activity Analysis Approach to measure Productivity efficiency in Agriculture (A case study of Ahmednagar & Nasik District.) *Indian Economic Journal*, 12(3), January-March, 1975, 211-231 p.

Bhat, M L : Crop-yield Index as a Measure of Inter District, Variations in Agriculture Productivity—A case of Bihar State, *Seminar on Methodology of Studying Productivity in Agriculture*, (Memo) Institute of Agricultural Research Statistics, 1970.

Bhattacharya, N & Saini, G R : Farm size and productivity : a fresh look. *Economic & Political Weekly*, 22 June, 1972, A 63-A. 72 p.

Chattopadhyay, M & Rudra, A : Size-productivity revisited. *Economic & Political weekly*, 11(39), 1976, A. 104-A. 116 p.

Chattopadyay, P : Indian farms : Need for Productivity Budgeting. *Capital*, 177 (4438), 11 Nov. 1976, 682-684 p.

———————— Mode of Production in Indian Agriculture. *Economic and Political weekly*, 25 March 1972.

Dahiya, L N : Impact of optimum agricultural land patterns on farm incomes. *Indian Journal of agricultural Economics*, 31(1), Jan.-March 1976, 23-29 p.

Dasgupta, A K : Productivity of Labour in Indian Agriculture, *Seminar on Methodology of Studying Productivity in Agriculture*, Institute of Agriculture Research Statistics, 1970.

Datta, HD : Productivity of Grass Land and Fodder Crops in Relation to other Farms Crops. *Seminar on Methodology of Studying Productivity in Agriculture*. Institute of Agriculture Research Statistics, 1970.

George, M V & Gangwar, A C : Measurement of Agricultural Productivity : Some Conceptual Problems. *Seminar on Methodology of Studying Productivity in Agriculture*, Institute of Agricultural Research Statistics, 1970.

Dey, A K : Rates of growth of agriculture and Industry. *Economic & Political Weekly*, 10(25), June 1975, A 26-A 30 p.

Dey, A K & Ashok Rudra : Crop allocation patterns—spurious quadratic cost curves. *Economic & Political Weekly*, 1973, 8(50), 2231-2234 p.

Dhameja, N L & Rao C V : Capital Productivity in plantation industry, *Productivity*, 18(2), 1977, 287-293 p.

Dhindsa, K S : An analysis of structural changes in agriculture. *Productivity*, 21(4), 1981, 541-552 p.

Evenson, R L & Kislev, Y : Research and Productivity in wheat and maize. *Journal of Political Economy*, 81(6), November 1973, 1309-1329 p.

Gangwar. A C & Singh, Parmatma : Impact of Green Revolution on Farm Labour. *Eastern Economist*, 24 May 1974.

Ghosh, R : Some experiments on aggregate agricultural production function for fifty districts of India. *Economic Affairs*, 16(1-2), Jan.-Feb. 1971, 9-24 p.

Hanumanthe Rao, C H : Factor Endowments, Technology and Farm Employment : Comparison of East Uttar Pradesh with West Uttar Pradesh and Punjab. *Economic & Political Weekly*, 25 Sept. 1976.

Jain, S C & Others : Productivity of resources of wheat crop. In Tarai agriculture. *Agricultural Situation in India*, 25(12), March 1971, 1265-1268 p.

Joshi, N C : Agricultural Productivity. *Kurukshetra*, 25(2), 1976, 12 p.

Kadaskodi, Gopal : Allocation Efficiency in Indian agriculture. *Productivity*, 16(1), 1975, 518-533 p.

Kahlon, A S & Bal, H K ; Factor share in output growth in Indian agriculture : A production function approach. *Productivity*, 18(2), 1977, 187-202 p.

Kahlon. A S & Kaul, J L : Productivity in Indian Agriculture *Seminar on Methodology of Studying Productivity in Agriculture*, Institute of Agriculture Research Statistics, 1970.

Kainth, G S : Impact of new farm technology on farm produce In Punjab. *Productivity*, 21(3), 1980, 401-414 p.

Kanthi, G S & Dhaliwal, P : The theories of production—A survey. *Arthe Vikas*, 11(1), 1975, 1-32 p.

Kaul, J L & Others : Differential growth of productivity in Punjab. *Journal of Research*, 9(3) 1972, 485-491 p.

Krishnan, K S : Factors influencing Agricultural Productivity In the Districts Covered under the intensive Agricultural District Programme. *Seminar on Methodology on Studying Productivity in Agriculture*, Institute of Agricultural Research Statistics, 1970.

Kuppuswamy, M : Modernising rice mills for increasing productivity. *Productivity*, 18(2), 1977, 241-244 p.

Kymal, P K : A new strategy for agricultural development to maximise production and to promote rural development. *Agricultural Situation in India*, 30(6), Sept. 1975, 433-435 p.

Lau, Lawrence J & Pan, A Tytopoulos : A Test for Relative Efficiency and Application to Indian Agriculture, *American Economic Review*, 61(1), March 1971, 94-109 p.

Lavania, G S & Singh, R P : Productivity of Family Labour in Agriculture. *Seminar on Methodology on studying Productivity in Agriculture* (Memo) Institute of Agricultural Research Statistics, 1970.

Mishra, J P & Others : Resource use and farm productivity, *Eastern Economist*, 66(25) 1976, 1332-5 p.

Mishra, R S & Others : Farm size, productivity and returns to scale. *Eastern Economist*, 1976, 67(15), 729-32 p.

Mohammed, Shafi : Measurement of productivity of the Great Indians. *Geographer* 19(1), 1972, 4-13 p.

Mohan, R, Jha D & Evanson, R E : Contribution of Research and Extension to Productivity Change in Indian Agriculture, *Economic and Political Weekly*, 28 September 1974.

Nair, N K : Contribution of Fertilizer to Food production in India—Some Estimates. *Productivity*, 17(1), 1976, 107-126 p.

———————— : Education in production : The case of Indian agriculture, *Productivity*, 15(3), 1974, 352-368 p.

Pal, Sasanka Shekar : Productivity of farm labour in the context of rural unemployment. *Economic Affairs*, 18(5), May 1973, 241-48 p.

Pandey, S M : Agricultural productivity, adoption of new technology and small farmers : An interest analysis. *Productivity*, 16(1), 1975, 542-553 p.

———————— : Wage Determination in Indian Agriculture—An Empirical Analysis, *Indian Journal of Industrial Relations*, 9(1), 1973, 83-100 p.

Pandya, A C : Impact of farm mechanisation on agricultural productivity. *Productivity* 18(2), 1977, 245-248 p.

Parikh, Ashok : Cropwise Districtwise Production Functions. *Indian Journal of Agricultural Economics*, 25(1), Jan.-March 1970, 43-58 p.

Patnaik, U : Economics of Farm size and Farm scale : Some Assumptions Re-examined. *Economic & Political Weekly*, Special Number, 1972.

Ram Krishan & Tyagi, B N : Study of growth rate of area, production and productivity of wheat crop in Uttar Pradesh. *Agricultural Situation in India*, 28(2), May 1973, 83-87 p.

Rao, S K : Inter-Regional Variations in Agricultural Growth, 1952-53 to 1964-65. *Economic and Political Weekly*, 3 July, 1971.

Rath, N : Rapporteurs report on benefit cost analysis of agricultural projects. *Indian Journal of Agricultural Economics*, 28(4), Oct. 1973, 247-256 p.

Rathor, M S & Others : Resource use efficiency and returns from some commercial crops of Himachal Pradesh. *Agricultural Situation in India*, 30(7), Oct. 1975, 507-510 p.

Rudra, Ashok : Marginalist explanation for more intense labour input in smaller farms. *Economic & Political Weekly*, 8(22), 2 June 1973, 989-994 p.

Saini, G R : Holding size, Productivity and some related aspects of Indian agriculture. *Economic & Political Weekly*, 6(26), June 1971, A 79-A 85 p.

Sankhayan, P L & Sindhu D S : The Size of the farm and productivity, *Northern Economist*, April 1974.

Sankhayan, P L & Sirchi, A S : Resource Productivity and allocation efficiency of seed potato, *Indian Journal of Agricultural Economics*, July-Sept. 1971.

Sewhney, D S : People's participation in agricultural productivity, *Productivity*, 12(4), 1972, 506-512 p.

Setharaman, S : Impact of fertilisers on agricultural production and productivity. *Productivity*, 18(2), 1977, 219-226 p.

Sharma, K D : Contributions of Crop improvement research to agricultural productivity. *Productivity*, 18(3), 1977, 401-414 p.

Sharma, Prem S : Impact of Farm Size on Agricultural Productivity in India : A Cross Sectional Analysis. *Agricultural Situation in India*, 26(8), Nov. 1971. 543-73 p.

Sharma, R K : Tractorisation and farm Productivity. *Productivity*, 16(1), 1975, 534-541 p.

Sharma, Ravindra : Farm production functions and labour productivity on small farms. *Agricultural University Journal of Research*, 18(1), January 1970, 75-92 p.

Singh, R D Verma. K K & Others : Production Possibilities and Research use pattern on small farms : A Comparative Study in three Regions of Uttar Pradesh. *Indian Journal of Agricultural Economics*, Oct.-Dec. 1972.

Singh, J P : Growth of factor shares in Indian Agriculture. *Productivity*, 15(1), 1974, 80-87 p.

———— Resource use, farm size and returns to scale in a backward agriculture. *Indian Journal of Agricultural Economics*, April-June 1975.

Singh, Jawala Prasad : Productivity of crops in Indian agriculture. *Productivity*, 18(2), 1977, 169-188 p.

Singh, K : Agricultural Productivity in the Punjab State. Growth, gap and variation. *Journal of Research*, 11(2), June 1974, 214-218 p.

Singh, Raj Vir : Labour productivity and size of farm, *Indian Journal of Industrial Relations*, 8(2), 1972, 245-253 p.

Singh, R V & Parel, R K : Resource productivity, allocation efficiency and farm size. *Agricultural Situation in India*, 1974, 28(12), 827-9 p.

Singh, V S : Agricultural trends in Uttar Pradesh, *Eastern Economist*, 12 Oct. 1973, 703-8 p.

Sirohi, A S & K N S : A Comparative Study of Farm Labour Productivity in some selected regions of India. *Seminar on Methodolcgy of Studying Prcductivity in Agriculture*, Institute of Agricultural Research Statistics. 1970.

Sisodia, J S: Agricultural production trends in Madhya Pradesh, *Agricultural Situation in India*, 28(9), Dec. 1973, 621-628 p.

Soni, R N : The impact of the size of land holdings and tenurial arrangements on resources allocation (A case study of the Punjab). *Journal of Agricultural Economics*, Oct.-Dec. 1970.

Srinivasan, T N : Farm Size and Productivity : Implications of Choice under uncertainty. *Sankhya*, 34(4), 1972, 409-20 p.

Srivastava, R S L : Productivity of Human Labour in agriculture and its mobility in rural labour market. *Indian Journal of Economics*, 52(206), Jan. 1972, 259-68 p.

Swaminathan, M S : Agricultural productivity in independent India. *Productivity*, 12(3), 1971, 389-392 p.

Tambad, S D & Patel, K V : Crop Yield Index as Measure of Productivity, *Economic and Political Weekly*, 20 June 1970, 979-80 p.

Usha Rani : Size of Farm and Productivity. *Economic & Political Weekly*, 26 June 1971.

Vyas, V S : Regional imbalances in foodgrains production in last decade, some preliminary results. *Economic & Political Weekly*, 1973, 8(52), A. 151-A. 156 p.

3. INDUSTRY

A. BOOKS

Abernathy William J : *The Productivity dilema : Rcadblcck to innovation in the automobile industry*. London; John Hopkins, 1978, 267 p.

——————: Wage Share in Organised Manufacturing Industry. *Productivity*, 15(1), 1974, 88-96 p.

Dandapani, S : Productivity and profitability : study of a railway cooperative. *Yojana*, 14(1,2,3,), 21 Feb. 1971, 29-30 p.

Dhesi, Autar : Productivity, Human Capital Intensity and Stages of Economic Development *Productivity*, 17(3), 1976, 401-416 p.

George, T A : Productivity incentives scheme in Hindustan Insectides Ltd. *Productivity*, 14(1), Suppl, 1973, 57-66 p.

Ghose, P P : Inter-State differences in the productivity of labour in India. *Journal of Social and Economic Studies*, March 1971.

Goel, V K & Nair, N K : Labour productivity and out put growth in Indian mining manufacturing sectors during 1961-76. *Productivity* 20(2). 1979, SI-541 p.

Gupta, G S : Economic of scale in Cement Industry *Economic & Political Weekly*, 29 March 1975.

——————: Production function and factor productivity in the Indian Cement Industry. *Indian Journal of Industrial Relations*, 8(3), 1973, 359-386 p.

Gupta, G S & Patel K : Production function in Indian sugar industry, *Indian Journal of Industrial Relations*, 11(3), 1976, 315-337 p.

Haridasan, S : Productivity agreements : the rationale behind them and their applicability to the Indian Industrial scene, *Labour Chronicle*, 5(1), 1972, 29-31 p.

Jaiswal, M C : Capital Productivity, Distribution of Capital & wages capital ratios in Indian Industries, *Journal of Gujarat Research Society*, Vol. 25.

Jaiswal, M C & Jain, B B : Productivity of Cotton Textile Industry in India, *Productivity*, 16(1), 1975, 575-592 p.

Joshi, Navin Chander : New dimensions in industrial productivity *Indian Horizons*, 23(4), 1974; 40-48 p.

Lal, B B : A note on Productivity and Economic Growth (with special reference to India), *Indian Journal of Economics*, July 1974.

Laxminarain, S : Whither textile productivity ? *Indian Textile Journal*, 91(7), April 1981, 61-64 p.

Mehta, BC & Madnani, GMK : Size, technology and productivity in cement industry in India. *Productivity*, 14(3), 1973, 249-253 p.

Mehta, Kanti : Productivity in the mining industry, *Indian Worker*, 25(13), 27th December 1976, 6-7 p.

Mehta, SS : Returns to Scale and Sources of Growth of output in large-scale industries *Indian Journal of Industrial Relations*, 11(3), 1976, 339-350 p.

Mukherjee, I N : Productivity trends in large scale manufacturing industry : a comparative study. *Productivity* 16(1), 1975, 560-574p.

Narasimhan, G : Productivity measures taken in Hindustan Aeronautics Ltd., Koraput Division, Delhi, Proceedings of the *Seminar on Higher Productivity in Public Sector Production Enterprises*, September 12-13, 1975. 123-139p.

Oomen, MA : Economics of Scale and Productivity Change In the Indian Manufacturing Industry. *Productivity*, 16(1), 1975, 554-559.

Peri Sastry, MVV : Measurment of productivity in mining : A case, *productivity*, 21(3), 1980, 343-356 p.

Pothural, DK : Labour Productivity in industry *Eastern Economist*, 57(21), 19 November 1971, 904-910p.

Radhakrishnan, T & Garde, AR : Impact of inputs of productivity. *Indian Cotton Mills Federation Journal* 17(10), February 1981, 11-20p.

Ram Pat : Labour Productivity in different sectors of Indian Economy, *Indian Journal of Economics*, July 1974.

Rakesh Kumar : Productivity study in small scale industry : a case study. *Productivity*, 15(4), 1975, 439-442 p.

Rao, BP : Productivity linked bonus. *Productivity*, 21(2), July-September 1980, 233-36 p.

Rao, S. Kishan : Productivity, gains and accounting for growth in Indian railways, 1951-74, *Productivity*, 18(3), 1977, 379-392 p.

Sahu, KC : Concepts of and approaches to productivity in service sectors in India. *Integrated Management*, December 1975. 15-23 p.

Sarkar, TC : Productivity in railway operation. *Productivity*, 16(3), 1975, 947-954 p.

Savar, Monorama : Labour and productivity in the Tea Industry, *Economic and Political Weekly*, 17 March 1973.

Savilani, Hasmukh D : Productivity linked bonus : Application and apprehension. *Indian Worker*, 28(16-17), 28 January 1980, 15 p.

Shaligram, KR : Critical factors affecting capacity utilisation In Iron & Steel Industry in India during 1955-56, *Productivity*, 18(3), 1977, 363-378 p.

Shankar, Tilak and Prahailad, CK : Productivity Measurement. A case study, *Indian Management*, April 1971.

Singh, R & Lakshminarayan B : Productivity in rolling mills. *Productivity*, 16(1), 1975, 593-599 p.

Sonwanshi, SA : Bonus and productivity in India : A conceptional framework. *Southern Economist*, 18(20), 15 February 1980, 17-20 p.

Stanislao, Joseph & James, Charles F : Improved manufacturing techniques and productivity, *Productivity*. 17(1), 1976, 26-37p.

Sukkhankar, LM : Productivity in manufacturing industry and PMTS. *Udyog Pragati*, 5(1), January-March 1981, 11-14 p.

Tatha, Raghao : Sector and system measures of labour productivity in the Indian Economy. *Indian Labour Journal*, 17(3), March 1976, 405-412 p.

Thakur, Sushila · Productivity in small firms. *Productivity*, 12(4), 1972, 502-505 p.

Verma, SL : A study of productivity in the iron and steel industry in India. *Man Power Journal*, October-March 1969-70.

Yeong-Har-Yesh : Returns to scale in Indian Industry, *Indian Economic Journal, Econometric* Annual, 1966.

————— : Per capita annual earnings of workers in manufacturing industries, *Eastern Economist* (Annual Number), 1975, 1296, 1299.

————— : Public sector and productivity, *Chartered Accountant*, 20(8), February 72, 635-36, Editorial

————— : The growth pattern of labour productivity in organised industries, 1964 to 1975-76. *Monthly Comm. on Indian Economic Conditions* 22(1), August 1980, 83-96 p.

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LETTER FROM THE EDITOR-IN-CHIEF

This issue which is third in the series since changes have been introduced in the Journal, brings to you a selection of articles in various fields of management and important sectors of the economy. Our next issue will be specially devoted to the theme of improving the 'Quality of Working Life' with a mix of selected articles from experts within India and abroad.

In recent years the human race has undergone a dramatic change and full impact of this change has yet to be perceived. In fact, the pace of change in social and technological areas has been so rapid that it has overwhelmed mankind both in developed and developing countries. The consequent cultural and perceptual lag has given rise to a number of human problems which are intricate and interwoven. It is to resolve these problems in an orderly and evolutionary manner that human effort has to be given a new thrust and dimension to promote harmony between the inner-self and the outer-surrounding.

Economic growth process in developing countries is largely determined by the promotion of human and social welfare and the basic faith in the dignity of man to work for the future which is the mightiest level of growth. In achieving this growth, there are problems of expansion both in technical and human resource requirements which are influenced by environmental factors, governmental policies and sociological demands. Higher productivity through promotion of efficiency in the use of resources requires a firm belief that human resource is the most versatile and most essential resource and like all other resources it needs to be properly trained, developed and motivated before it can be put to effective use.

Science and technology have transcended the national boundaries and affected the lives of human beings throughout the world. While technological progress has truly shrunk the world into a compact unit without any boundaries, the progress achieved the world over has been rather uneven. The North, for example, continues to be the pace setter for technological change and is in command of most of the resources whether they be financial, technical or otherwise, while the South still continues to be steeped in poverty, squalor and disease. In developing economies there is always a lurking danger of a heavy dose of technology without due regard to the extent to which manpower resources can be mobilised and put to effective use. Import of technology by itself cannot subserve any useful purpose if it is to the detriment of local talent and competence. Any forward leap from a stage of development to a sophisticated industrial production must ensure that people imbibe the technology and are able to use it for the economic and social good. This calls for a radical change in the education system to meet the needs of modernising both industry and agriculture and evolving a "culture in which "inter" and "intra" transfer of technology becomes an inalienable part of the application of modern and sophisticated technologies.

Promotion of science has to be made more relevant to national needs with the involvement of scientists, academics and professionals and by seeking closer involvement of scientists to promote a "science of humanism" which will usher in a new culture which can confidently stand by humanity in the coming decades and prepare them for an onward march beyond 2000 A.D.

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Recent Trends in Sectoral Terms of Trade

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This study analyses changes in the domestic terms of trade between the industrial and agricultural sectors of Indian economy. It reveals that these terms have turned in favour of agriculture during 1960-1975. The disparity in behaviour of two sectors is attributable to relatively lower price elasticities of industrial products in face of variations in demand and supply.

The principal mechanism most frequently mentioned in the literature on economic development is the fluctuation in the relative prices of the goods and services inter-changed between the sectors. The movements of relative prices cause sectoral resource movements by changing the relative profitability of production and investment in different sectors of the economy. The relationship between agricultural and non-agricultural prices influences (a) incentive to produce within the agricultural sector, (b) the distribution of income not only between agricultural and non-agricultural sectors, but also between high and low income groups in a society, and (c) the rate of capital formation in manufacturing industries, through direct and indirect effect caused by the role of agriculture as a supplier of industrial raw material and wage goods. This study, therefore, endeavours to analyse the changes in the domestic terms of trade, between the agricultural and industrial sectors.

Unless otherwise specified the following discussion refers to the commodity terms of trade which in our two sector economy (consisting of agricultural and Industrial sectors) may be defined as the ratio of the index of agricultural prices to the index of the industrial prices with a reference to a common base year in which indices of both prices are equated to 100.

Methodology

The time reference of the study are the fifteen years from 1961-62 to 1975-76. The data on the prices of various commodities available in India pertain to annual whole-sale prices and are expressed in the form of Index Numbers.

These are available in three series with 1951, 1961-62 and 1970-71 prices as the base years. In this study we have used the series commencing in 1961-62 with that year as the base year. These are issued by the Economic Advisor to Govt. of India and are reported by the Reserve Bank of India.

Trend parameters for the prices of various commodities in India were computed by using the principle of least square of estimation. Annual growth rates were worked out by dividing the trend co-efficients by the average price index for each commodity. From the indicies of prices, trends of the ratios between the prices of (1) the agricultural and industrial goods, and (2) food-grain and industrial commodities were computed. A non-parametric test based on the ranking of each observation has been applied for the significant existence of the trend. This technique, primarily used for study of short series, does not assume any form of relationship, for example straight line or curve, between the variables.

The fluctuations in the prices were studied by calculating percentage variations for different periods. This analysis was further supported by calculating the upward and downward flexibility of the prices. These flexibilities were computed by taking the deviations of the maximum and minimum price index from the average price index under the study period.

Results and Discussion

The short period of time to be studied and large year to year fluctuations pose major problems for statistical analysis. Firstly, the differences in trends among the prices and price relationship which are of great economic significance may be reduced to statistical insignificance. Secondly, working with a short time series with large fluctuations will make a large difference to the trend measures. Extreme values placed at one end or the other of a short time-series have a very major effect on the slope of the trend. Since industrial prices are not so heavily influenced by weather, the relationship between agricultural and industrial prices will also be influenced by the choice of the period under consideration. Thus, there is bound to be uncertainty and controversy concerning past trends in relative prices. The trend values and the growth rates of the whole-sale prices of various commodities drawn from both the agricultural and non-agricultural sectors are presented in Table 1.

Table 1

Trend parameters for prices of various commodities in India, 1961-62 to 1975-76.

No.	Commodity	Weight	Base year 1961-62=100 Trend Value	Growth rate
1.	Intermediate products	97	15.860	8.769
2.	Pulses	27	22.309	8.748
3.	Milk-Ghee	61	16.356	8.297
4	Metal Products	38	13.810	8.161
5.	Chemicals	7	14.996	8.111
6.	Cereals	121	16.328	8.086
7.	Oil Seeds	52	15.463	7.677
8.	Fibres	41	11.431	7.169
9.	Fruit-Vegetables	23	12.472	6.894
10.	Textiles	113	9.454	6.363

Table 1 depicts the trend values and growth rates for the whole-sale prices of various commodities drawn from both the agricultural and non-agricultural sectors. It will be seen from Table 1 that during the study period different commodities have shown quite different rate of growth of whole sale prices. Intermediate manufacturers (8.7 per cent) and pulses (8.7 per cent) have shown the greatest price increases while fruit-vegetables (6.894 per cent) and textiles (6.363 per cent) the least. Thus, it is evident that the top two and the bottom two in the rate of growth of prices include one from the industrial group and one from the agricultural group. Taking weighted average of groups, we find the growth rate as follows :

Commodity Group	Growth rate (per cent per annum)
Industrial raw material Crops (7, 8)	7.881.
Industrial products (1, 4, 5, 10)	7.376
Food-grains (2, 6)	8.207
Agricultural Groups (2,3,6,7,8 & 9)	9.064

It is evident from this that the agricultural prices during the study period have risen more rapidly than the industrial prices. This seems to be merely due to more rapid increases in foodgrain prices. On the other hand, Industrial raw-material crops had gone up more rapidly than the Industrial prices.

The trend of the ratios between the prices of (1) Agricultural and Industrial goods, (2) Foodgrains and Industrial commodities, and (3) Foodgrains and non-foodgrains, were worked out and the results are reported in Table 2.

Relative Prices of Foodgrains to Non-foodgrains

From Table 2, it is evident that the terms of trade remained unfavourable to non-foodgrains during the study period. It appears that a greater

Table 2

Estimates of Relative Prices Between Foodgrains-Industry, Agricultural, Non-Foodgrains and Foodgrains in India : 1961-62 to 1975-76

Year	Price Indices				Ratio's		
	Foodgrains	Agriculture	Non-Foodgrains	Industry	Foodgrains / Industry	Foodgrains / Non-Foodgrains	Agricultural / Industry
1	2	3	4	5	6	7	8
1961—62	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1962—63	104.28	101.96	101.97	103.56	100.69	102.26	98.45
1963—64	123.84	116.01	107.73	106.19	116.62	114.95	109.31
1964—65	145.57	133.00	117.49	113.37	128.40	123.89	117.31
1965—66	158.74	152.49	135.32	125.28	126.51	117.31	121.31
1966—67	207.49	188.45	149.79	131.52	157.76	138.52	143.06
1967—68	206.95	180.78	144.50	132.63	156.04	143 22	136.31
1968—69	192.74	186.91	160.41	142.61	135.15	120.15	131.06
1969—70	214.48	203.92	172.82	154.48	138.84	124.11	132.01
1970—71	200.20	202.27	184.63	168.68	118.69	108 43	119.99
1971—72	223.15	195.98	188.48	184.91	120.68	118.39	105.99
1972—73	245.49	289.95	212.54	193.79	126.68	115.50	123.82
1973—74	332 43	326.49	282.43	250.30	132.81	117.70	130.44
1974—75	298.20	303.11	281.09	259.59	114.88	106.09	116.77
1975—76	267.31	266.09	963.55	202.29	101.91	101.43	101.45

rise in prices has been experienced in the case of foodgrains as compared to non-foodgrains. Similarly, in the downswing foodgrain prices have fallen less than non-foodgrain prices. For the ratio of the foodgrains to non-foodgrain prices (column 7 of Table 2), the calculations show the

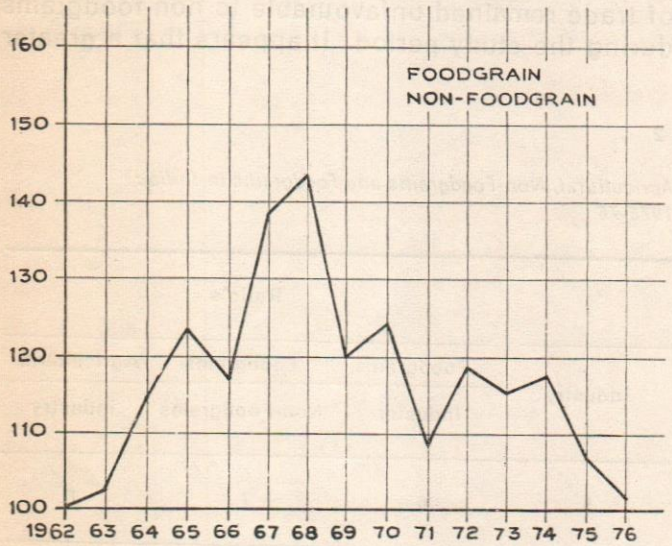

Fig. 1 : Relative prices of foodgrains to non-foodgrains

total score of 87 and the Kendall's rank co-relation co-efficient of 0.83. This co-efficient was significant at one per cent level. The conclusion is that the trend in the terms of trade between foodgrains and non-foodgrains has been towards food-grains. This finding is consistent with the observation of the growth rate of the various commodity groups.

Relative Prices of Foodgrains to Industrial Products

So far as the terms of trade between foodgrain and the industrial sectors are concerned, it remained favourable to the foodgrains during the entire period of study. A greater improvement in the ratio between the foodgrains and industrial prices was experienced in 1966-67 in which terms of trade rose to 157.76. The statistical calculation shows the total score of 79 and the rank co-relation co-efficient of 0.75. This was significant at one per cent level. This suggests the movements against the prices of industrial sector, a finding consistent with the growth rate of various commodities.

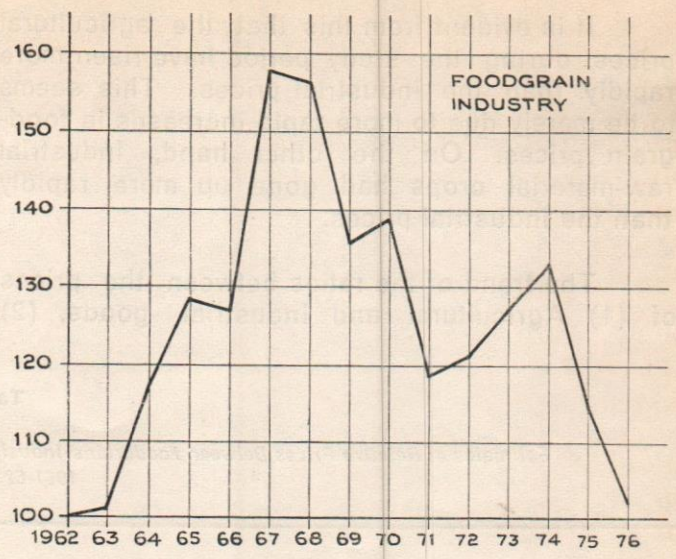

Fig 2 : Relative prices of food-grains to industrial products

Relative Prices of Agricultural to Industrial Products.

The analysis shows that the term of trade remained favourable to the agricultural sector during the study period with the only exception of the year 1962-63 in which the terms of trade were favourable to the industrial sector. The ratio of agricultural to industrial prices rose from

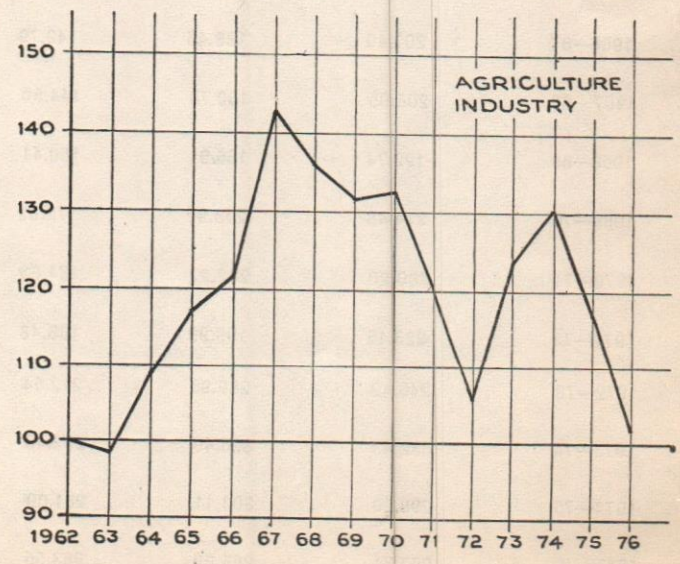

Fig. 3 : Relative prices of agricultural to industrial products

98.45 in 1962-63 to 143.06 in 1966-67-an increase of 45.31 per cent. Although this ratio declined to 130.44, it was still 23.49 per cent higher than the figure of 1962-63. Thereafter it has shown a declining trend. The statistical calculation showed the total score of 80 and the Kendall's rank correlation co-efficient of 0.76 which was significant at one per cent level. The conclusion is that the trend in the terms of trade has been significantly in favour of the agricultural sector. Again this is primarily because of the behaviour of foodgrain prices. It will be noted that foodgrains bear a much lighter weight in the weighted average than their relative importance in total production. In a discussion of changes in relative prices, however, it seems relevant to weight by marketing rather than by production as has been done. From the foregoing discussion, we conclude that the terms of trade remained favourable for the agricultural sector. The terms of trade have been favourable for the agricultural product as a whole as well as for their major constituent namely foodgrain, but they are more favourable for the latter than the former.

These statistics, however, are subject to many reservations and should be interpreted with caution. Many statistical problems are associated with the method of compiling the price series from which these trends are computed. Some of these reservations are the adequacy of the sample used, the relative weights assigned to different commodities, the absence of provision for changes in quality, shifting of coverage due to the appearance of new and disappereance of the old commodities and the treatment of transportation costs.

The movements in the terms of trade profoundly influence the income redistribution from one sector to another and thereby the growth of an economy. A recent study on sectoral distribution of income by this author shows that during 1960-61 to 1977-78 there has been a transfer of Rs. 6582 crores from non-agricultural to agricultural sector. In the Indian context agriculture, being the major sector of the economy both in resources and output, must make a substantial contribution to the financing of the development of non-agricultural sector. This is possible only when the income of farm sector is transferred to non-farm sector. Since the Government finds it difficult, due to socio-political reasons, to impose additional fiscal burdens like agricultural income tax and higher land revenue, for mobilizing agricultural resources necessary for the growth of an efficient industrial sector, making the terms of trade adverse for agriculture would be a less painful device available. Since the whole issue is a complex one and there is no single solution to this problem, many devices, fiscal and para-fiscal, will have to be adopted in combination at different points for different commodities for siphoning off agricultural surpluses for economic growth.

Turning from the question of trend, it clearly emerges from figure 1 that during the period of study there have been two periods of relatively declining and relatively rising agricultural prices. During the first six years namely, 1961-62 to 1966-67 agricultural prices increased relative to non-agricultural prices. For the next five years that is, 1967-68 to 1971-72 the agricultural prices tended to fall. Again, in the next two years, that is 1972-73 through 1973-74, the agricultural prices once again showed an upward trend. For the last two years, they are once again declining. Undoubtedly, during the two series of years of consequtively rising prices the pressure on wages and on profit must have had significant and deleterious effect on the development of the non-agricultural sector. However, each period of relative decline in foodgrain prices must have had a counter-balancing effect.

The tendency for sharp fluctuations in agricultural production and for runs of successively declining and rising relative prices calls for care in making judgements about the performance of agricultural sector and in making prescription for that sector. It is, therefore, imperative to analyse the movements of the components of agricultural and non-agricultural prices in order to show the pattern of domestic terms of trade. The percentage variations in the farm and non-farm sector and also of the component of both the sectors were computed. The results obtaind are reported in Table 3.

It will be seen from Table 3 that during the period 1961-62 to 1966-67 agricultural prices increased by 88.15 per cent whereas manufactured prices increased by only 31.52 per cent. Thus, in the increased phase agricultural prices increased more than the manufactured prices. During the period 1966-67 to 1971-72, the agricultural prices increased only by 4.16 per cent whereas

Table 3

Percentage variation in Agricultural and Industrial prices for different periods.

Item	1966-67 over 1961-62	1971-72 over 1966-67	1973-74 over 1971-72	1975-76 over 1973-74
Agricultural Prices	+ 88.15	+ 4.16	+66.59	—18.49
Foodgrains	+107.49	+ 7.55	+66.42	—19.09
Pulses	+159.00	+ 9.77	+59.87	—23.52
Cereals	+ 96.00	+ 6.89	+47.87	— 6.91
Fruit vegetables	+ 78.00	+ 1.63	+68.71	—18.28
Milk-Ghee	+ 67.00	+29.04	+42.04	— 0.75
Raw Material Prices	+ 73.73	+ 4.12	+85.52	—28.32
Fibres	+ 29.00	+20.54	+54.95	— 3.98
Oil Seeds	+109.00	— 3.88	+98.06	—40.69
Industrial Price	+ 31.52	+40.59	+35.36	+ 7.79
Chemicals	+ 50.90	+31.74	+36 22	+15.62
Metal Products	+ 28.00	+48.75	+34.66	+16.19
Intermediate Products	+ 48.50	+39.96	+49.88	+ 0.03
Textiles	+ 23.00	+38.78	+26.65	+ 0.87

industrial prices increased by 40.59 per cent. Again, during the period 1971-72 to 1973-74 the agricultural prices increased by 66.59 while the manufactured prices increased by 4.79 per cent. Thus, in the falling phase agricultural prices fell more than the industrial prices. The hypothesis that the agricultural prices fell more than the industrial prices in the following falling and rising phases respectively, can be further strengthened by the upward and downward flexibilities of the prices of various commodities. The upward and downward flexibilities were worked out as explained in the section methodology and are reported in Table 4.

It will be seen from Table 4 that agricultural prices have had greater flexibilities than the industrial prices both in the upward and downward directions. The upward and downward flexibilities were computed respectively at 69.03 and 48.23 per cent for the agricultural sector. The corresponding figures for the industrial sector were 61.93 and 38.26 per cent. Thus, agricultural prices have greater flexibility than the industrial prices both in the up and down swing.

If we analyse the movement of the components of agricultural and industrial prices similar results are obtained. During the period 1961-62 to 1966-67 cereals prices increased by 96.00 per cent and pulses prices increased by 158.00 per cent. In case of milk-ghee and fruit vegetables, the increase in prices was 67.00 and 78.00 per cent. During the period 1966-67 to 1971-72, the prices of all the agricultural commodities increased slightly. The price rise was 7.55, 9.77, 6.89, 1.63 and 29.04 per cent for foodgrains, pulses, cereals, fruit-vegetables and milk-ghee respectively. Over the period 1971-72 to 1973-74, the prices of all agricultural commodities once again increased. The price rise was 66.42 per cent

Table 4

Upward and Downward Flexibilities for Prices During 1961-62 to 1975-76 in Per Cent

Items	Upward Flexibility	Downward Flexibility
AGRICULTURAL PRICES	69.03	48.23
Foodgrains	65.07	50.34
Pulses	79.10	60.79
Cereals	91.25	50.48
Fruit-Vegetable	61.69	44.73
Milk-Ghee	72.17	49.27
RAW MATERIAL PRICES	83.46	47.41
Fibres	60.87	37.91
Oil Seeds	97.56	53.31
INDUSTRIAL PRICES	61.97	38.25
Chemicals	77.36	45.91
Metal Products	76.04	40.91
Intermediate Products	72.19	44.71
Textiles	52.45	32.09

for foodgrains, 59.87 per cent for pulses, 47.87 per cent for cereals, 68.71 per cent for fruit-vegetables and 42.04 per cent for milk-ghee. After 1973-74 pulses recorded the largest decline followed by fruit-vegetables and the cereals. The fluctuations of the components of agricultural prices were further supported by the upward and downward fllexibilities. The corresponding upward and downward flexibilities were computed to be 65.07, 79.10, 91.25, 68.69 and 72.17 per cent and 50.34, 60.79, 50.48, 44.73 and 49.27 per cent respectively for foodgrains pulses, cereals, fruit-vegetables and milk-ghee.

Let us now analyse the movements of raw material prices and its components, namely, fibres and oil seeds. Raw materials and its components also exhibited similar flexibilities and percentage variations. Between 1961-62 to 1966-67, raw material prices increased by 73.73 per cent, fibres prices by 29.00 per cent and oil seeds prices by 109.00 per cent. During 1966-67 to 1971-72, whereas the oil seeds prices declined by 3.28 per cent, the prices of raw materials and fibres increased by 4 12 and 20.54 per cent respectively. Again, during the period 1971-72 to 1973-74, the price of raw material and its components increased considerably. The price rise was 98.06 per cent for oil seeds, 85.52 per cent for raw material and 64.95 per cent for fibres. During the next three years, namely, 1973-74 to 1975-76, its price shows a declining trend. The decline was noted to be the highest in oil seeds (40.69 per cent) followed by raw material (28.32 per cent) and fibres (3.98 per cent). This trend of prices was further supported by the upward and downward flexibilities. In the up and down swing, oil seeds showed greatest flexibilities (97.56 and 53.31 per cent), followed by raw material (82.46 and 47.41 per cent) and fibres (60.87 and 37.91 per cent).

On the contrary, manufactured prices showed less fluctuations both in the up and down trend as compared to agricultural prices. During 1961-62 to 1966-67 the chemicals rose by 50.90 per cent, metal products by 28.00 per cent, intermediate products by 48.40 per cent and textiles by 23.00 per cent. For the period 1966-67 to 1971-72, the price rise was 31.74 48.75, 39.96 and 38.78 per cent respectively for chemicals, metal products, intermediate products and textiles. The corresponding rise in the prices of the products during 1971-72 to 1973-74 and 1973-74 to 1975-76 were respectively of the order of 36.22, 34.66, 49.88 and 26.65 per cent and 15.62, 16.19, 0.03 and 2.87 per cent. The upward and downward flexibilities of the prices of these goods further supported the same trend. Chemicals exhibited the maximum flexibilities both in the up and down swing, the numerical value being 77.36 and 45.91 per cent. The corresponding figures for metal products, intermediate products and textiles were of the order of 72.19, 76.04 and 52.45 per cent, and 44.71, 40.90 and 32.69 per cent. From the foregoing discussion we come to the conclusion that agricultural prices have shown greater fiexibilities both in the up swing and down swing as compared to the industrial prices. The greater flexibilities of the agricultural prices is suggestive of the low price elasticities of demand and supply of agricultural products. Demand for agricultural products being less price elastic, price changes more disproportionately with a given change in the production of agricultural commodities. Similarly, the supply being less price elastic, it does not change sufficiently with change of the price. On the other hand, the relatively low variation of industrial prices suggests that the price elasticities of demand and supply of industrial products is comparatively higher.

Conclusions

1) The agricultural prices during 1960-61 to 1975-76 have shown much sharper rate of increase than the industrial prices. This is on account of more rapid increase in foodgrain prices. On the other hand, industrial raw material crops have gone up more rapidly than industrial prices.

2) The analysis reveals that the terms of trade between the agricultural and non-agricultural sectors of the Indian economy have turned in favour of agricultural sectors during the study period with the only exception of the year 1962-63. As between foodgrains and non-foodgrains the terms of trade have turned in favour of the foodgrains.

3) The movements of the domestic terms of trade in India during the study period has been largely due to greater variation in agricultural prices. Compared to industrial prices, agricultural prices have tended to show greater flexibilities both in the up swing and in the down swing of

the business cycle. This disparity in the behaviour of agricultural and industrial prices may be attributed to relatively lower price elasticities of demand for and supply of agricultural products viz-a-viz industrial products.

Implications

A number of important implications follow from the discussion of the terms of trade between agricultural and non-agricultural sectors. Firstly, given the probability co-efficients the domestic terms of trade are not likely to turn against the agricultural sector during the early stages of development. Thus, the capital contribution from the agricultural sector is not likely to arise from a change in the terms of trade and, therefore, reliance must be placed upon other means of drawing such a contribution. Secondly, the domestic terms of trade will trend so radically towards agriculture as to create a major political problem. That is, if the terms of trade do turn towards agriculture, it will be by so small amount as to be relatively undetectable within a period of few years.

Finally, when agriculture is the main sector, per capita incomes are largely determined by the levels of production of agricultural commodities. This is suggestive of the fact that the potential contribution of the agricultural sector should be recognised. Thus, the agricultural sector should be given separate treatment in the models dealing with the early stages of economic growth.

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Commitment to Unionism

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This study explores factors underlying the phenomenon of 'commitment' to unionism. The findings reveal that anti-management sentiments alone are unlikely to generate commitment but socio-work related factors are likely to act as intervening variables in the commitment.

In a rapidly changing work environment one of the tasks confronting union leaders is, how to evoke and sustain commitment to unionism. While there is little consensus concerning the definition of the concept or its measurement most scholars have conceived of commitment as involving some form of psychological bond between people and organization.

When we try to associate commitment to unionism as an institution, it denotes a psychological bond between its members and the institution. It means eliciting a regular and active response to union activities from its clientele throughout the life of the organization. This response has three primary components : (a) identification—adoption as one's own, of the goals and values of trade unionism as an institution, (b) participation—psychological immersion or involvement in the activities of one's role in the union, and (c) allegiance—a feeling of affection for and attachment to the trade union. As such adoption of, participation in, and attachment to, the institution of unionism should connote commitment to it.

Commitment embraces multi-farious activities viz., regular payment of subscription, participation in union elections, canvessing for the candidates, visits to union offices, reading union's literature, honouring strike calls, attending union sponsored programmes, donation of funds, attending union meetings regularly, and the like. Out of these indices many have been explored in the past by researchers but no conclusive evidence or fool proof generalizations have been offered

as at times one or the other variables were reported to be associated with commitment and on other occasions this association was non-existent.

The level of commitment to unionism in Indian situation has been repeatedly reported to be low. Crouch (1966), reports disinterest on the part of the Indian worker in union activities. Pandey and Vikram (1969) in their study of trade unionism in the building industry mentioned that members participation in union activities is generally low. Sheth (1969), and Sharma (1974) also found that the level of participation was low in Indian situation. Sheth reported considerable apathy or hostility among workers towards union work. Sharma (1974) in his study of union involvement found that workers show a relatively high degree of interest in unions and have a favourable attitude towards them. But this relatively high interest in unions is not converted into active participation in union activities.

It has also been reported that participation in union activities is high during the course of trouble in the plant. Dean (1954), found that unionists usually concur that success or failure in "getting the members out to meeting tends to vary with the amount of trouble that exists in their plant at any given time. When there is trouble, they say you have to hire a hall to pull them all in but when things are normal, it is "let 'X 'do it". Participation has, also, been viewed as the progeny of the presence of anti-management attitudes. Active union participation is taken by some as a manifestation of workers' discontent with the management or its policies (Sharma 1974). Seidman et. al., (1958), also report that the average member of a union is indifferent or apathetic to it with regard to its day-to-day work. Crouch (1966), describes the Indian worker as status conscious, possessing a persistent mentality to obey and hence disinterested in union work. Dayal and Sharma (1970), in their study of Banking Industry, relating to clerical staff, mention that althougha vast majority of clerical employees are members of unions and consider unions necessary, they are not highly interested in them. They pay union dues quite regularly but attend union meetings only rarely. In view of the foregoing studies, the low level of commitment to unionism is discernible in the existing situation.

As per the definition of commitment to unionism given in this text the three main factors associated with it are identification with, participation in and allegiance to the institution of unionism. On the basis of these a commitment index could be worked out and for this purpose attendance at the union meetings and payment of subscription regularly were identified as the significant variables. These two were considered as better indices, for the simple reason that attendance at union meeting requires lot of time and it satisfies all the three factors listed above to a large extent. Regular payment of subscription involves monetary sacrifice on the part of the members which would be made only when they identify themselves with the organization and owe allegiance to it. Moreover, attendance at union meetings affords direct member involvement in union strategy formulations and leads to union effectiveness. While talking about union effectiveness Dayal and Sharma (1970), conclude that the success or failure of a union depends among other things, on the presence of certain attitudes among members, as well as, on their level of participation (attendance in union meetings) in union activities. Hence, attendance at union meetings and payment of subscription has been taken as apriori basis for judging commitment to unionism in the present study.

The study, therefore, has the following objectives :

1) To explore whether an anti-management attitude sustains interest in unionism.

2) To identify whether there are some socially relevant and job-related factors which influence worker commitment to unionism.

Keeping in view the above objectives the following hypothesis were formulated :

1) Anti-management attitude among the workers is not the only factor generating commited to unionism.

2) Socially integrated workers are more likely to be committed to unionism.

Methodology

The data for the study was collected from two unions in Haryana having a following of

about 13,000 (7000+6000). A sample of 297 respondents was selected through systematic random sampling and the attendance records of these members at various union meetings and status of subscription payment was examined. The respondents were grouped on the basis of the foregoing criterion of commitment and 20 respondents were dropped for the reasons given ahead. Respondent's perception relating to concern for their personnel welfare of unions and management, their social circle composition, job-liking, perception of union as an institution, performance of their unions, and perceived quality of work life and of management's concern for people was elicited through a structured questionnaire. The sample was divided almost fifty-fifty on the basis of years of experience. Those having less than 5 years of experience numbered 139 whereas those having more than 5 years numbered 138.

Commitment to unionism has been broken down into two extremes, high and low, and the mid-point was deliberately eliminated in order to have a clear picture of the commitment. The respondents cwere lassified into these two catagories on the basis of their attendance and subscription, records of which were maintained by the unions. Those who attended more than 50 per cent of the union meetings and had no arrears of membership fee were grouped under highly committed and those who attended 50 per cent or less and had accumulated arrears were clubbed under the low level of commitment. (There were eight respondents who had no arrears but less than 50 per cent attendance at union meeting and 12 who attended more than 50 per cent meetings but had arrears. These could be categorised under medium level of commitment but were dropped keeping in view the insignificant number and to facilitate analysis.) Thus, we had the following frequency distribution of the respondents with regard to commitment to unionism :

Commitment to Unionism

Percentage of meetings attended and position of subscription payment	Level of commitment	N
Less than 50 percent and arrears	Low	141
More than 50 percent and no arrears	High	136

The data was further grouped to form a scale of social integration in order to test the second hypothesis. In this scale 'friends in the plant' was the first item, 'length of service' the second 'item and' job liking was the third. Scores were assigned from 3 to 0, on the basis of the response to these items. Respondents with a score of 3 were considered "high" on social integration : they had many friends in the plant, five or more years of experience and liked their jobs 'very much' or 'fairly well; respondents with a score of 2 were categorised as medium on integration: had a few friends in the plant, but the same degree of job-liking and experience as those scoring 3. Respondents with a score of 1 had no friends in the plant, less than 5 years experience but high on job satisfaction. Those scoring 'O' had no friends in the plant, less than 5 years experience, were indifferent to or disliked their jobs. Respondents scoring 0 and 1 were clubbed to facilitate analysis.

The data was cross-tabulated and corrected co-efficient of contingency was calculated to test the association between social integration and commitment to unionism.

Research Evidence

Table 1 presents the data relating to respondents perception of the concern of unions and employers about their welfare. The statistics

Table I

Would you say that the head of the company or the head of the union is more interested in your personal welfare ? The head of the union, the head of the company, both are equally interested neither is interested ?

Sr. No.	Who is interested in my personal welfare	Level of Commitment to Unionism High	Low	N
1.	Union	35(25.61) (70.00)	15(10.97) (30.00)	50(18.07) 100.00
2.	Company	8(5.78) (20.51)	31(21.95) (79.49)	39(14.07) 100.0
3.	Both	90(66.11) (71.42)	36(25.60) (28.57)	126(45.48) 100.0
4.	Neither	3(2.50) (4.83)	59(41.48) (95.17)	62(22.38) 100.0
	Total	126(100.0)	141(100.0)	277(100.0)

X^2 at 3 d.f. 96.25 C=0.7408

conveys that those who perceived that both unions and employers were interested in their personal welfare were high on the scale of commitment (66.11) : or, in other words, highly committed employees were, likely to have a positive perception of both the parties. These were the respondents who regularly attended union meetings and paid subscription regularly. The chi-square test shows a significant relation ship between the perception about the union and management and commitment to unionism. An important clue which emerges out of this analysis is that the positive attitude towards both unions and managements is indicative of the decline of traditional militancy as a motivation for participation in union activities and implies, instead, the existence of dual allegiance among the workers (Monga, 1978). The traditional view has been that an antagonistic attitude towards employer provoked commitment to unionism (Dean, 1954) but the present findings connote that lack of this attitude has not hindered the commitment to unionism. In fact, those workers who held a positive view towards both management and union were higher on commitment than those who supported only one institution. (Table II.) Thus, the presence of an antagonistic attitude

Table II

Respondents Perceived Attitude Towards Unions and Management

Sr. No.	Perceived Attitude	Level of commitment to unionism High	Low	N
1.	+Union +Management	90(66.17) (71.42)	36(25.53) (28.57)	126(45.48) (100.0)
2.	+Union —Management	35(25.73) (70.00)	15(10.63) (30.00)	50(18.05) (100.0)
3.	—Union +Management	8(5.88) (20.51)	31(21.98) (79.49)	(3914.07) (100.0)
4.	—Union —Management	3(2.22) (4.83)	59(41.86) (95.17)	62(22.38) (100.00)
	Total	136(100.0)	141(100.0)	277(100.00)

X^2 at 4 d.f. 86.026 significant C=0.7100

was insufficient to explain commitment to unionism ? What does explain it ? There are certain factors which covertly influence commitment to unionism. This is an issue which has been further explored below.

Commitment to unionism : the determinants

In order to explore the above question it was hypothesised that the workers affiliation outside the plant during rest hours, his length of service and his job-liking may have either an explicit or implicit impact on his commitment to unionism. Therefore, social group composition of the union members was studied to know the extent to which it was composed of co-workers in the plant and the data was cross-tabulated to know their level of commitment. The results indicate that the more a worker was associated with co-workers during rest hours the more likely he was to possess a high level of commitment to unionism (Table III). The impact of experience

Table III

Among the friends you associate with most frequently outside the plant, about how many work within your factory ? (Many of them, just a few, none of them)

Sr. No.	Friends from the work-premises	Level of Commitment to Unionism High	Low	N
1.	Many of them	61(44.81) (66.16)	38(26.95) (38.38)	99(35.74) (100.0)
2.	Just a few	32(23.52) (28.57)	80(56.73) (71.43)	112(40.43) (100.00)
3.	None of them	43(31.61) (65.15)	23(16.32) (34.84)	66(23.83) (100.00)
	Total	136(100.0)	141(100.0)	277(100.0)

X^2 at 2 d.f. 30,78 C=0.4613

was also examined and it was found that the greater the experience the higher the percentage of those possessing a high level of commitment to unionism and the less the experience the higher the percentage of those having a low level of commitment to unionism (Table IV). Dayal and

Table IV

Length of Service of the respondents

Sr. No.	Length of service	Level of commitment to unionism High	Low	N
1.	Below 5 years	53(38.97) (38.12)	86(60.99) (61.88)	139(50.18) (100.0)
2.	Above 5 years	83(61.03) (60.14)	55(39.01) (39.86)	138(49.82) (100.00)
	Total	136(100.0)	141(100.0)	277(100.0)

X^2 at 1 d.f. 12.97 C=0.3318

Sharma (1970), in a study on Banking industry concerning clerks found an association between work experience and union involvement. Sharma (1974) found a positive association between seniority and participation in union activities. The X^2 test, also, disclosed a significant association between experience and commitment. The findings indicate that the higher the experience in industrial life, the greater the sense of affiliation and identification with the peer community and therefore, the higher the level of commitment to unionism. Workers' job liking was found to be another important factor likely to affect commitment as a higher percentage of those who liked their jobs very much were committed to a high level of participation in union activities. Out of those who liked their jobs very much about 78 per cent were highly committed to unionism, whereas, the percentage of those who were highly committed in spite of disliking their jobs was 15.45 percentage only. It was not the workers who disliked their jobs but those who liked their jobs who possessed a higher level of commitment to unionism (Table V).

Table V

How well do you like the actual job you perform ? (Like very much like fairly well; neither like nor dislike; dislike a little, dislike very much)

Sr. No.	Job-liking	Commitment to Unionism High	Low	N
1.	Like very much	106(77.94)	31(21.98)	137(49.45)
		(77.37)	(22.63)	(100.0)
2.	Like fairly well	9(6.61)	43(30.49)	52(18.77)
		(19.30)	(82.70)	(100.0)
3.	Indifferent or dislike	21(15.45)	67(47.53)	88(31.78)
		(23.86)	(76.14)	(100.0)
	Total	136(100.0)	141(100.0)	277(100.0)

X^2 at 2 d.f. — 88.64 C—0.7182

However, Dayal and Sharma (1970), found no association by and large between work satisfaction and commitment to their union in case of bank officers. These results corroborate the earlier findings and enable us to reject our first hypothesis that it was the antagonistic or discontented worker who was committed to unionism. In fact, a more satisfied worker having a positive attitude and interaction in the plant community was likely to possess a higher level of commitment. The workers who had a clear sense of personal identification with the plant, its life and its institutions were more likely to be highly committed to unionism.

All the three factors mentioned above namely, length of service, affiliations outside the plant, and attitude towards unions and management represent a Gutman type scale which can be used to workout a concrete level of social integration in order to test its impact on commitment to unionism.

Social Integration and Commitment to Unionism

Social integration has been variously defined by different authors but for the purpose of present analysis it means involvement of the members in the plant and community life based on their interaction with job and social contextual factors Table VI presents a distribution of the sample

Table VI

Social Integration and Commitment to Unionism

Sr. No.	Level of Social Integration	Level of Commitment to Unionism High	Low	N
1.	High	97(71.32)	39(27.65)	136(49.09)
		(71.32)	(28.68)	(100.0)
2.	Medium	23(16.91)	29(20.56)	52(18.77)
		(44.23)	(55.77)	(100.0)
3.	Low	16(11.77)	73(51.79)	89(32.14)
		(17.97)	(82.03)	(100.0)
	Total	136(100.0)	141(100.0)	277(100.0)

X^2 at 2 d.f. 68.25 significant at 0.01 level C = 0.6486

on the basis of their level of social integration and commitment to unionism. The data indicates that the higher the level of social integration, the higher the percentage of those committed highly to unionism. Out of 136 respondents possessing high level of social integration, about 71.32 per cent were high on commitment to unionism. Similarly out of those at the medium level of integration about 44 per cent possessed a high level of commitment to unionism. Thus, the more a worker was integrated into the life of the plant and liked his job, the more likely he was to be committed highly to unionism. The corrected

co-efficient of contingency bears out this relationship between the two.

The preceeding relationship, of course, is probably not basic at all and might be influenced by certain background factors or by different attitudes a worker has toward the plant, the union or the management. To examine the compactness of the relationship a number of background variables and some attitude items were controlled but none of these factors modified the basic relationship between social integration and commitment to unionism.

The question then tested was : Do workers' basic attitudes towards the union, the plant and the management tend to take precedence over social integration in determining commitment to unionism e.g. might not workers lacking a pro-union ideology refrain from participating in union activities no matter what their level of social integration into the life of the plant? What about workers who were passive about the plant as a place to work i.e. who perceived quality of work life negatively ?

To further cross-examine the relationship between social integration and commitment to unionism four variables were controlled. The first was workers attitude towards unions as an institution (Table VII). It was found that among

Table VII

Attitude Towards Unions as an Institution

Sr. No.	Attitude	Level of Commitment to Unionism High	Low	N.
1.	**Positive Social Integration**			
	High	65(47.7) (82.27)	14(9.92) (17.73)	79(78.51) (100.0)
	Medium	14(10.29) (53.84)	12(8.51) (46.16)	26(9.38) (100.0)
	Low	15(11.02) (48.38)	16(11 34) (51.62)	31(11.19) (100.0)
2.	**Negative Social Integration**			
	High	22(16 17) (68.75)	10(7.09) (31.25)	32(12.95) (100.0)
	Medium	12(8.23) (40.00)	18(12 76) (60.0)	30(10.83) (100.0)
	Low	8(6.5) (10.12)	71(50.38) (89.88)	79(27.14) (100.0)
	Total	136(100.0)	141(100.0)	277(100.0)

X^2 at 5 d.f. 88.742 significant C= 0.7185)

those having high social integration and a positive view of unions, a higher percentage possessed a greater level of commitment to unionism. Again among those with a medium level of social integration a higher percentage had a high level of commitment to unionism and a positive view of the unions as an institution. Out of those who viewed unions negatively and had a low level of social integration, a higher percentage possessed a low level of union commitment. On the other hand, interestingly, among those holding a negative opinion about unionism, the percentage of highly integrated and possessing a high level of commitment to unionism was higher, thus eliminating negative attitudes towards union. The corrected value of C, also, bears out the relationship between social integration and commitment to unionism.

The attitude towards union leaders, also, could not influence the relationship between commitment to unionism and social integration (Table VIII). Among those holding a positive

Table VIII

All things considered do you think that union leaders are : doing a good job, doing a fair job; doing a poor job for the workers ?

Sr. No.	Perception of Union leader's side	Level of Commitment to Unionism High	Low	N
1.	**Positive Social Integration**			
	High	36(41.48) (81.15)	13(9.21) (18.85)	69(24.90) (100.0)
	Medium	10(7.35) (34.48)	19(13.37) (65.52)	29(10.46) (100.0)
	Low	9(6.61) (45.0)	11(7.80) (55.0)	20(7.22) (100.0)
2.	**Negative Social Integration**			
	High	31(22.79) (79.48)	8(5.67) (20.52)	39(14.07) (100.0)
	Medium	20(24.70) (60.60)	13(9.21) (39.40)	33(11.91) (100.0)
	Low	10(7.07) (11.49)	77(54.64) (88.51)	87(31.44) (100.0)
	Total	136(100.0)	141(100.0)	277(100.0)

X^2 at 5 d.f. 179.94 C=0.8201

view of union leaders and possessing a high level of social integration, a higher percentage (81.15) had a high level of commitment to unionism. Similarly among those who had a negative view about union leaders and low level

of social integration a higher percentage was low on the scale of commitment to unionism. Therefore, the more integrated were likely to have high level of commitment to unionism regardless of their views about union leaders. The calculated corrected value of C also corroborates the association between the two, irrespective of the attitudes being positive or negative.

When perceived quality of work-life in the plant, was controlled, the results indicated that better integrated were more likely to have high commitment proneness (Table IX). Of 127

Table IX

All things considered how well do you like working at your plant ?

Sr. No.	Perceived Quality of work life	Level of Commitment to Unionism High	Low	N
1.	**Like very much Social Integration**			
	High	59(43.78)	14(9.92)	73(26.35)
		(80.82)	(18.17)	(100.0)
	Medium	13(9.55)	17(12.05)	30(10.83)
		(43.33	(56.67)	(100.0)
	Low	11(8.08)	13(9.21)	24(8.66)
		(45.83)	(54.17)	(100.0)
2.	**Like less or dislike Social Integration**			
	High	30(22.05)	6(4.25)	36(12.98)
		(83.33)	(16.67)	(100.0)
	Medium	21(15.44)	19(13.47)	40(14.40)
		(52.5)	(47.5)	(100.0)
	Low	2(1.50)	(2751.10)	74(26.78)
		(1.70)	(97.30)	(100.0)
	Total	136(100.0)	141(100.0)	277(100.0)

X^2 at 5 d.f. 112.00 significant C=07012

who had a positive perception of the quality of work life, about 46.45 were high on both social integration and commitment level. Again out of 73 who were high on integration, 80 per cent were found high on commitment also. Similarly, among those who disliked the quality of work-life and were lowly integrated a very high percentage (about 97 per cent) was low on commitment to unionism. In addition, the attitude towards management's concern for people was controlled to further test the relationship (Table X), It was

Table X

Do you feel that managements in your plants are interested in maintaining good conditions for the workers ?

Sr. No.	Perceived management's concern for people	Level of Commitment to Unionism High	Low	N
1.	**Positive Social Integration**			
	High	67(49.26)	17(12.05)	84(30.32)
		(79 76)	(20 24)	(100.0)
	Medium	6(4.41)	11(8.51)	18(6.49)
		(33.33)	(66 67)	(100.0)
	Low	11(8.07)	9(6.38)	20(7.22)
		(55 0)	(45.0)	(100.0)
2.	**Negative Social Integration**			
	High	21(15.44)	16(11.34)	37(13.35)
		((56.75)	(43.25)	(100.0)
	Medium	10(7.35)	11(7.80)	(21(7.58)
		(46.61)	(52.39)	(100.0)
	Low	21(15.47)	76(53.92)	97(35.04)
		(21.64)	(79.36)	(100.0)
	Total	136(100.0)	141(100.0)	277(100.0)

X^2 at 5 d.f. 81.150 significant C=0.6221

found that better integrated were more likely to be committed. Among those holding a positive attitude towards management (122 respondents) about 69 per cent had high social integration and of those about 80 per cent also had a high degree of commitment to unionism. Likewise, among those having negative perception about management (155) only 24 were highly integrated and also high on commitment whereas 63 per cent were lowly committed and of this 78 per cent were also low on commitment to unionism. The corrected value of C also supports the relationship between social integration and commitment regardless of the nature of attitudes. Hence, the earlier relationship persists; that is better integrated workers were more likely to have a higher level of commitment to unionism and were likely to possess positive attitude towards management and unions.

Favourable attitudes and a higher level of social-integration seem, in many cases, to combine and act as a motivation to greater commit-

ment to unionism. Social integration, probably was a more important variable, however, since the results indicate that its relationship with commitment persists even where attitudes did not predispose participation in union activities.

Conclusions and Implications

This study mainly explored the factors underlying the phenomena of commitment to unionism. Whether it was purely anti-management attitudes and disposition which sustained commitment or whether other factors also contributed to it. The first hypothesis on probing, could not be supported, as anti-management sentiment was not sufficient to evoke commitment to unionism. It could be true in case of trouble and tension but not in a situation of calm or in the absense of any anti-management impetus. In such situations the high level of commitment to unionsm was found to be associated with certain other factors like job-liking, experience and association outside the plant. In other words, the level of social integration of the members had its influence on their commitment to unionism. Social integration could be viewed as an interactive element at the unit level which engineers and sustains commitment to unionism.

The findings have a special relevance and message for union leaders who are in search of active members and are looking for way to sustain workers commitment to unionism. They need not raise the bogey of anti-management attitudes to achieve workers commitment but can instead attempt to develop better social-interaction among the plant community, and improve the community life and quality of work life in the plant through increased involvement of rank and file. A hostile attitude toward management and its policies would not sustain members' interest for long. Perennial disagreement with management will not create sustained interest in unionism on a stable basis but certain intervening variables like the quality of work life, quality of community life, the presence of socially relevant work, and contextual factors etc. are likely to play a vital role and evoke commitment to unionism. Unionists must work for the presence of these factors in the interest of their own survival as well as that of the institution.

The study has some implications for management also. They should try to encourage social interaction among the workers and provide such facilities outside the plant life as would facilitate social integration. A better integrated worker is not likely to sway or swim with the union verdict but is likely to posses a dual allegiance and decide each situation on a rational basis. Therefore, the development of a socially cohesive and relevant environment around the work situation would pay dividends to all i.e. the worker, the unions and the managements.

REFERENCES

1. Crouch, H., *Trade Unions and Politics in India.* Bombay : Manaktalas, 1966, pp. 28-29.

2. Pandey, S. M. and C. M. Vikram, Trade Unionism in Delhi's Building Industry, *Indian Journal of Industrial Relations* 1969, 4(3) 309.

3. Sheth, N. R. Workers Participation in Trade Union Activity," *Indian Journal of Industrial Relations*, 1969, 4 (3) 283.

4. Sharma, B. R., *The Indian Industrial Worker-Issues in Perspective*, Bombay; Vikas Publishing House, 1974, p. 126.

5. Sheth, N. R. and S. P. Jain, Workers, Leaders and Politics—A Case Study, *Indian Journal of Industrial Relations*, 1968, III, (3).

6. Dean, Louis R., Social Integration, Attitudes and Union Activity, *Industrial and Labour Relations Review* Vol. 8, 1954, p. 51.

7. Seidman, Joel et. al., *The Worker Views His Union*, Chicago : University of Chicago : Press, 1958, p. 178.

8. Dayal Ishwar and Baldev R. Sharma, *Draft Report on Emplcyer Employee Relations in Earks*, IIM, Ahmedabad, pt. I and II, 1970, p. 10.

9. Monga, M. L., The Worker Speaks His Mind—A Study of Company and Union Allegiance, *Indian Labour Journal* 1978 Vol. 19, No. 6 pp. 859-864.

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Goal Programming Approach To Product —Mix Decisions—A Case Study

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Profit maximisation is seldom the sole objective of an organisation. Other organizational goals include minimisation of costs, meeting minimum commitments, generation of a minimum revenue and maximum utilization of plant capacity. This paper illustrates potential of the goal programming technique for making strategic decisions in face of multiple goals.

This study relates to product—mix decision making in a company undertaking manufacture and sale of professional electronic products. An attempt has been made in the study to illustrate the potential of the Goal Programming technique for making strategic decisions of this nature.

The company where the study was conducted is identified as ABC Company. (The actual name has been disguised). At present it has nearly 3000 employees and an annual turnover of Rs. 12 Crores. The product-line of the company is very broad, ranging from large sophisticated Micro-wave Communication Systems to small hand-carried Communication sets in the VHF (very high frequency) range. For the purpose of this study, all products were categorized into ten categories. The products included in each category have almost identical capacity requirements of various production shops and almost the same selling price and unit profit.

Each year, the company formulates a production programme for the next year after considering its present order book position, immediate commitments and capacity availability in production shops. This is done quantitatively by matching the capacity requirements of each product in various production shops with the respective available capacities, providing for augmentation of capacity if necessary or curtailing production of some products not considered priority items on an empirical basis The optimality of the product-mix decision arrived at using this approach is, however, uncertain, since an

integrated view is not taken of various aspects relating to the decision viz., capacity utilization, profitability, sales budget, demand forecast etc.

The Goal Programming Appreach : A close look at the decision environment of the product-mix decision of the company revealed that the company was striving to achieve a number of objectives by choosing the optimum product-mix. These are :

i) to make reasonable profit out of its operations.

ii) to achieve a desired level of sales turn-over.

iii) to meet the most immediate sales commitments of the year.

iv) to achieve maximum capacity utilization.

It is apparent that all these objectives can not have the same importance. Each objective must have its priority and the objective with the utmost priority must be achieved first.

The achievement of objectives is also limited by a set of constraints of various nature. These constraints may be absolute, in which case the upper limits set by the constraints cannot be exceeded at all; or they may be preferential constraints, in which case, it is preferable but not absolutely essential that the upper limit set by the constraint not be exceeded.

The Goal Programming approach is ideally suited to a decision environment of this nature and using this approach, optimum product-mix decision can be readily arrived at.

Data Base : The following information is required for the formulation of a Goal Programming Model :

i) list of objectives with their priorities, stated explicitly.

ii) constraints of capacity, demand, etc.

iii) product-wise capacity requirements, profit margins, sales value etc.

iv) any other non-quantitative factors pertaining to the decision environment.

The objectives as stated by the 'key managers' of the company in their priority ranking were as follows :

i) To meet the immediate sales commitments of the next year, namely

Product-1	:	1 unit
Product-3	:	4 units
Product-5	:	3 units
Product-6	:	1000 units
Product-8	:	10 units
Product-9	:	150 units
Product-10	:	1000 units

ii) To achieve sales value target of Rs. 18 crores as projected.

iii) To achieve a surplus of Rs. 4 crores from operations of the Company next year.

iv) To achieve maximum capacity utilization of 2,00,000 hours each in fabrication and assembly shops. (giving equal weightage to each shop).

v) To achieve sales of the following products as targetted to accelerate capture of the market :

Product-2	:	6 units
Product-4	:	20 units

Constraints : The following constraints were identified :

a) The available capacity of fabrication and assembly shops is 2,00,000 hours each. However, these constraints are not absolute, since, by overtime operation or by sub-contracting, capacity can be enhanced.

b) Owing to a large cycle time involved in procurement of materials, manufacturing and testing activities etc. more than one unit of Product 1 cannot be made during the year. Product-7, for similar reasons cannot be taken up in the assembly shop at all during the year.

c) The maximum demand for some of the

products has been forecast as follows:

Product-2	:	10 units
Product-3	:	12 units
Product-4	:	60 units
Product-5	:	10 units
Product-6	:	2000 units
Product-7	:	3 units
Product-8	:	50 units
Product-9	:	500 units
Product-10	:	2000 units

d) The augmentation of capacity is limited to 25,000 hours in fabrication and assembly shops separately. The costs involved in further expansion of the capacity would be phenomenally high.

Product-wise Data

The product-wise data is placed in Table 1.

The following observations may be made :

i) Product-1 is already under production. The data presented here refers to the residual production value, work load and surplus expected.

ii) Product-3 has zero profit margin.

iii) Product-4 and Product-6 have their prices fixed below their cost of sales. Therefore, these have a negative profit margin.

Model Formulation :

The problem has been converted into a Goal Programming Model as shown below :

Constraint Equations :

1) $200\ x_1 + 60\ x_2 + 18\ x_3 + 1.25\ x_4 + 42\ x_5 + 0.12\ x_6 + 200\ x_7 + 9.5\ x_8 + 0.7\ x_9 + 0.20\ x_{10} + d_1^- - d_1^+ = 1800$

(Sales Value Constraint)

Table 1

Product-wise Data

Product Category	Unit Sales Value (Lakhs of Rs.)	Unit Surplus Value (Lakhs of Rs.)	Capacity requirement for one unit in fabrication shop (in hours)	Capacity requirement for one unit in assembly shop (in hours)
Product – 1	200	30	30,000	12,000
Product—2	60	8	6,500	3,600
Product—3	18	0	2,500	1,800
Product—4	1.25	-1.75	1,500	700
Product—5	42	10	6,500	3,000
Product – 6	0.12	-0.03	20	70
Product—7	200	50	40,000	0
Product—8	9.3	0.90	900	1,100
Product—9	0.70	0.10	50	100
Product – 10	0.20	0.02	20	50

2) $3000\ x_1 + 6500\ x_2 + 2500\ x_3 + 1500\ x_4 + 6500\ x_5 + 20\ x_6 + 40{,}000\ x_7 + 900\ x_8 + 50\ x_9 + 20\ x_{10} + d_2^- - d_2^+ = 2{,}00{,}000$

(Fabrication capacity constraint)

3) $12000\ x_1 + 3600\ x_2 + 1800\ x_3 + 700\ x_4 + 3000\ x_5 + 70\ x_6 + 0.0\ x_7 + 1100\ x_8 + 100\ x_9 + 50\ x_{10} + d_3^- - d_3^+ = 2{,}00{,}000$

(Assembly capacity constraint)

4) $30\ x_1 + 8\ x_2 + 0.0\ x_3 - 1.75\ x_4 + 10\ x_5 - 0.03\ x_6 + 50\ x_7 + 0.90\ x_8 + 0.10\ x_9 + 0.02\ x_{10} + d_4^- - d_4^+ = 400$

(Surplus constraints)

5) $x_1 + d_5^- = 1$

6) $x_3 + d_6^- - d_6^+ = 4$

7) $x_5 + d_7^- - d_7^+ = 3$

8) $x_6 + d_8^- - d_8^+ = 1000$

9) $x_8 + d_9^- - d_9^+ = 10$

10) $x_9 + d_{10}^- - d_{10}^+ = 150$

11) $x_{10} + d_{11}^- - d_{11}^+ = 1000$ (Immediate sales commitment constraints)

12) $x_2 + d_{12}^- - d_{11}^+ = 6$

13) $x_4 + d_{13}^- - d_{13}^+ = 20$ (Preferable sales constraints)

14) $x_7 + d_{14}^- = 3$

15) $x_2 + d_{15}^- = 10$

16) $x_3 + d_{16}^- = 12$

17) $x_4 + d_{17}^- = 60$

18) $x_5 + d_{18}^- = 10$

19) $x_6 + d_{19}^- = 2000$

20) $x_8 + d_{20}^- = 50$

21) $x_9 + d_{21}^- = 500$

22) $x_{10} + d_{22}^- = 2000$ (Maximum demand constraints)

23) $30{,}000\ x_1 + 6500\ x_2 + 25\ 0\ x_3 + 1500\ x_4 + 6500\ x_5 + 20\ x_6 + 40{,}000\ x_7 + 900\ x_8 + 50\ x_9 + 20 x_{10} + d_{23}^- = 2{,}25{,}000$

24) $12{,}000\ x_1 + 3600\ x_2 + 1800\ x_3 + 700\ x_4 + 3000\ x_5 + 70\ x_6 + 0.0\ x_7 + 1100\ x_8 + 100\ x_9 + 50\ x_{10} + d_{24}^- = 2{,}25{,}000$

(Overtime constraints)

Non-Negative Constraints

$x_1, x_2 \ldots\ldots\ldots\ldots x_{10} \geqslant 0$

$d_1^-, d_2^- \ldots\ldots\ldots\ldots d_{24}^- \geqslant 0$ and $d_1^+, d_2^+ \ldots\ldots d_{13}^+ \geqslant 0$

Objective Function

Minimize

$Z =$

$P_1 (d_5^- + d_6^- + d_7^- + d_8^- + d_9^- + d_{10}^- + d_{11}^-) P_2 (d_1^-) + P_3 (d_4^-) + P_4 (d_2^- + d_3^-) + P_5 (d_{12}^- + d_{13}^-)$

where,

x_j ($j = 1, 2, 3, \ldots\ldots\ldots 10$) is the number of units of a product to be produced in the coming year.

d_i^- ($i = 1, 2, 3, \ldots\ldots\ldots\ldots 24$) represent the under achievements

d_i^+ ($i = 1, 2, 3, \ldots\ldots\ldots 13$) represent the over achievement.

Solution of the Goal Programming Model

The solution of the Goal Programming Model using the standard algorithms is as follows :

Product-1	:	1 unit
Product-2	:	10 units
Product-3	:	4 units
Product-4	:	Nil
Product-5	:	4.15* units
Product-6	:	1000 units
Product-7	:	0.77* units
Product-8	:	10 units
Product-9	:	263.5 units
Product-10	:	1000 units

Non-Integer values for products 5, 7 and 9 are acceptable because the remaining work can be finished in the next period. Regarding the sales values, the customers are committed to make payments on part completion of a product. This is true especially in the case of products which have high sales value.

An analysis of the above Product-mix is given in Table 2. The following observations can be made :

i) The immediate Sales commitments as specified in the first objective are fully achieved.

ii) The Sales value target of Rs. 18 crores is also almost fully achieved.

iii) A total surplus of Rs. 215.43 lakhs is achieved as against desired objective of Rs. 400 lakhs.

iv) Capacity utilization of both fabrication and assembly shops is fully achieved.

v) Desired sales of Product-2 can be attained but that of product-4 cannot be attained.

Product-Mix Decision Using Present Practice :

The product-mix as obtained by the existing practice of matchining work load with capacity has also been worked out and is as follows :

Product-1	:	1 unit
Product-2	:	6 units
Product-3	:	4 units
Product-4	:	20 units
Product-5	:	3 units
Product-6	:	1000 units
Product-7	:	1 unit
Product-8	:	10 units
Product-9	:	150 units
Product-10	:	1000 units

Table 2

Analysis of Product-mix Decision Arrived At Using Goal Programming Model

S. No.	Product No.	Quantity (No. of units)	Sales Value (Lakhs of Rs.)	Surplus (Lakhs of Rs.)	Capacity requirement in Fabrication Shop (in hours)	Capacity requirement in Assembly Shop (in hours)
1.	Product—1	1	200	30	30,000	12,000
2.	Product—2	10	600	80	65,000	36,000
3.	Product—3	4	72	—	10.000	7,200
4.	Product—4	nil	—	—	—	—
5.	Product—5	4.15	174.3	41.5	26,975	12,450
6.	Product—6	1000	120	-30	20,000	70,000
7.	Product—7	0.77	154	38.5	30,800	—
8.	Product—8	10	93	9	9,000	11,000
9.	Product—9	263.50	184.45	26.35	13,175	26,350
10.	Product—10	1000	200	20	20,000	50,000
		TOTAL	1797.75	215.35	2,24,950	2,25,000

Table 3

Analysis of Product-mix Decision Arrived at Using Present Practice

S. No.	Product No.	Quantity (No. of Units)	Sales Value (Lakhs of Rs.)	Surplus (Lakhs of Rs.)	Capacity of Fabrication Shop (in hours)	Capacity of Assembly Shop (in hours)
1.	Product—1	1	200	30	30,000	12,000
2.	Product—2	6	360	48	39,000	21,600
3.	Product—3	4	72	0	10,000	7,200
4.	Product—4	20	25	-35	30,000	14,000
5.	Product—5	3	126	30	19,500	9,000
6.	Product—6	1000	120	-30	20,000	70,000
7.	Product—7	1	200	50	40,000	—
8.	Product—8	10	93	9	9,000	11,000
9.	Product—9	150	105	15	7,500	15,000
10.	Product—10	1000	200	20	20,000	50,000
	TOTAL		1501	137	2,25,000	2,09,800

An analysis of the aforesaid product-mix decision is placed in Table-3. It is observed from the table that a total sales value of only Rs. 15.01 crores can be achieved as against Rs. 18.00 crores achievable through the use of Goal Programming Model. Also, the surplus attainable would be reduced to Rs. 137 lakhs as against Rs. 215.43 lakhs achieved in the Goal Programming Model. Capacity utilization of both fabrication and assembly shops is fully achieved; however, less than the maximum permissible overtime is committed for assembly. The first objective, namely, meeting the immediate sales commitment has been achieved totally. The last objective, namely, achieving a desired sales level for Product-2 and Product-4 has also been fully achieved.

The comparison of the two product-mix decisions viz-a-viz the achievement of the objectives is given in Table 4. It clearly indicates that Goal Programming is definitely a superior method of arriving at Product-mix decision in conformity with the priority of objectives laid down by the Company.

Table 4

Comparison of Goal Programming Solution with Solution Based on Existing Practice

		GOAL PROGRAMMING SOLUTION	PRESENT SOLUTION
(i)	Achievement of Immediate Sales Commitments	Fully Achieved	Fully Achieved.
(ii)	Achievement of Sales Target	Almost Fully Achieved	Achieved upto Rs. 15.01 crores only
(iii)	Achievement of Surplus Target	Achieved upto Rs. 215.35 lakhs	Achieved upto Rs. 137.0 lakhs
(iv)	Achievement of Capacity Utilization	Fully Achieved	Fully Achieved
(v)	Achievement of Sales for Products—2 and Product—4	Product—2 achieved; Product—4 not achieved	Both Product—2 and Product—4 quantities achieved.

REFERENCES

1. Charnes, A and Cooper, W. W., *Management Models and the Industrial Applications of Linear Programming*, Vols. 1 & 2, New York : John Wiley, 1961, New York.

2. Charnes, A and Cooper, W. W. *Goal Programming and Multiple Objective Optimization*, Centre for Cybernetic Studies Report CCS-250, University of Texas, Austin, 1975.

3. Daver, J. P., and Krueger, R. J. An iterative approach to goal programming, *O. R. Quarterly*, Volume 28, 1977. pp. 671-681.

4. Ignizio, J. P., *Goal Programming and Extensions*, Lexington, : M A. D. C. Heath. 1976.

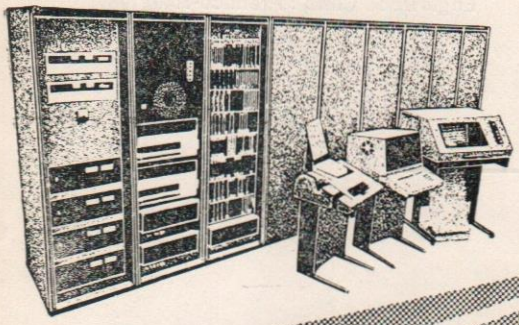
5. Johnson, J. H., Applying goal programming to multi-plant/ product aggregate production loading, *Western Elect. Engr.*, 1976, pp. 8-15.

6. Lee, Sang Decision Analysis Through Goal Programming *Decision Sciences*, Volume 2, No. 2, April 1971, pp. 172-80.

7. Lee, Sang M., Goal Programming For Decision Analysis, Auerbach Publishers, Inc , Philadelhia, 1972.

8. Wilde, D. J. and Brighter, C. S. *Foundations of optimization*, Englewood Cliffs : Prentice-Hall, 1967.

BEL ENTERS LSI ERA IN ICs



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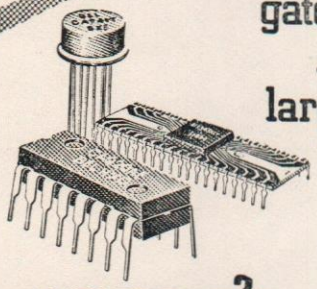

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Productivity
1981, XXII, 3, 27-31

Quality Assurance and Reliability of Sub-contracted Items

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A preliminary analysis and assessment of quality assurance and reliability while sub-contracting manufacture of parts of an end-product is made in this paper. The vital role of S.Q.C. charts in establishing coordination, control and information requirements of the integrated system is highlighted by the analysis.

There are many big organisations responsible for an end-product[1]—which incorporate parts which are sub-contracted. Actually, in India, the Government policy encourages ancillary units to supply semi-finished goods, and/or parts required in assembly or further processing for major public (and private) sector Industries. Some ancillary units are located in Industrial estates set up specifically for the purpose of meeting the requirements of major Industries. However, the quality (of end-product) is *the responsibility* of the major firm with *no* dilution or excuses because of sub-contracting to an ancillary firm.[2] An important function of the major firm is to ensure that the sub-contracting suppliers meet the quality requirements imposed by consumers of the end-product.

The major firm has to organise a quality assurance programme in which each sub-contracting supplier (of materials or service entering into the end product) would be required to enforce adequate quality control and record the relevant observational data. The acceptance by the major firm should be only after it is satisfied that the quality standard is established and maintained at the required level. Even if computer controlled operations are involved, it is essential that the controls established generate adequate support data—for evaluation of quality standard

1 The term "end-product' means the final product as assembled and/or processed by the Major firm and *finally* supplied to the receiving customers (or equivalent) by the Major firm.

2 For purposes of ideas considered in this paper, the major firm is referred to as the "Buyer"—and the sub—contracting ancillary firm as the "*Supplier*".

and variations. Here, both the acceptance programme and the information requirement are equally important. The responsibility for both these remain with the major firm, though *delegated responsibility* has to be and is accepted by the supplier firm for its part of quality control. It has to be emphasised, however, that the *entire responsibility* for all parts of (and composite) end-product *remains* with the major firm, and conformance to this quality by the supplying (ancillary) units has to be ensured, if necessary by the use of authority vested in the major firm, to approve or cancel the order placed.

Systems Approach and Use of Statistical Quality Control

A programme has to be set up to ensure both the functions of control and of information generation. The documents should be prepared prescribing general requirements of a quality control system to be set up by the supplier firm with access at any time for inspection and check by the buyer (major) firm. The Q.C. system should ensure that suitable and adequate quality control is maintained throughout the entire process of purchasing (raw materials), manufacturing, and inspection, and must extend to storage, packaging and stripping. The component or part life-history from the raw material to the stage of receipt and acceptance by the major firm should be available and assessed in objective quantitative terms. A suitable statistical programme and analysis becomes imperative. In-process Quality Control records along with the acceptance inspection results should present an integrated information. The generated statistical data with details of corrective actions taken and assignable causes eliminated should be available for the buyer (major) firm to follow the quality history and furnish reliability estimates to the end-product performance.

The techniques broadly and generally grouped under *Statistical Quality Control* are available for effective use in this process of Quality Assurance about the performance of the end-product. The supplier (ancillary) firm and the buyer (major) firm form a system, whose purpose is the manufacture and quality assurance of the part in relation with the end-product. The responsibility of system effectiveness is with the major-firm which certainly has the authority to operate (or terminate) the system. This approach considers the supplier and buyer as discrete parts of the same system, *interlinked* by a network of communications through which flow information causing cybernatic response. Such an approach ensures quality assurance and reliability requirements in the end-product which are the purpose and vital concern of this programme of manufacture. When the end-product does *NOT* involve any sub-contracted parts, this integrated system feature is assured by the major firm itself.

General Quality Control and Reliability Requirements

However, when sub-contracting is resorted to, this integrated system feature is to be carefully safeguarded and the relationship of Supplier-Buyer should *not* be merely some acceptance sampling procedures and contracts involving or including penalties as in market purchase. This would fall very much short of the requirements. "Reliability is the *probability* of a device performing its purpose *adequately* for the period of time intended under the *operating conditions* encountered". The supplier firm has to have a clearly designated set-up within its own organisation to receive the delegated responsibility for control of quality and also be endowed with sufficient authority to ensure that quality requirements are maintained. For effective implementation of Quality Control Programme, formal documentation consistent with the specifications of the part or component is to be made. The documentation should have the benefit of the scrutiny and approval of the buyer firm. It may be emphasised that buyer and supplier are to act in a co-ordinated way, *each* relying on the other for support in all efforts and passing on relevant information as and when necessary.

Suppliers Quality Control Programme (internal) should accept and approve before products are passed on to the buyer (acceptance) inspection. The buyer will also have the entire Quality Control records to "assess" the entire lot of production, and his acceptance sampling would serve as a check on this assessment. Supplier's quality history records, facilities and quality control system provide important information to the buyer.

In a technical sense, the "universe of production" is better estimated by these data

and information, and Acceptance Sampling procedures are designed to check these estimates. "The use of Control Charts for acceptance should find increasing use when purchase is over a long period : it is the universe that gives the standard for acceptance or rejection. If there is more than one universe submitted, we would have this information by the use of Control Charts for acceptance inspection." (Ekambaram, 1966) Reliability statements can then be scientifically made with associated probabilities as required from the Product Performance requirements.

It is helpful if engineers designing, manufacturing and inspecting the part or component have an appreciation of the concept of "universe of production" defining the standard of manufactured quality. When there is a single standard of quality, there is a single universe of production described by its frequency distribution, which in majority of cases of directly measurable quality is the well-known Normal Distribution.

Engineers taking samples, and collecting data for Quality Control and quality assurance should ensure that Rational Sub-groups are carefully formed. Everyone concerned should know the advantages of forming "Rational Sub-groups" at each stage of tests and control. The concept of "Rational Sub-groups" and also that of "Statistical universe of products should be clear in practice to Engineers involved in production in the ancillary firm and the major firm. In the words of Dr. W.A. Shewhart, the founder of the S. Q. C. Charts, "the Engineer who is successful in dividing his data initially into rational sub-groups based upon rational hypotheses is inherently better off in the long run than the one who is not thus successful."(1931)

The rational sub-groups are to be so formed such that quality variations *within* a sub-group are due only to chance causes inherent in the production process. If assignable causes occur or intervene, they should have possibilities *only* between one sub-group to another sub-group. Such a design of rational sub-groups would facilitate the detection, and also elimination, of the assignable causes if they should occur.

The methods of selection of rational sub-groups for ensuring that *within* sub-groups only chance causes operate are dealt with lucidly by E. L. Grant. The order of production is an important factor in such selection, though it must be emphasised that it is not a sufficient basis for sub grouping. The main consideration in the choice of sub-groups is the requirement that only a minimum (necessary) chance variation occur within a sub-group. This chance variation would represent the ideal process capability since *no* assignable causes are allowed to be present in the production process.

Co-ordination from Design Stage to the Acceptance Stage

The supplier facilities and competence are to be understood by the Buyer and essential Design restrictions fully appreciated. The design of the component should meet adequately the quality requirements of the end-product, but can build around the "strengths" of the supplier by suitable design adjustments or modifications. The important consideration is the end-product and its quality and reliability. As long as these are met, the supplier's component can have design adjustments to bring the component within the scope of the suppliers facilities and talents. Where some special strengths are seen (e. g. costs, skills) in the supplier, these can be given due consideration in the design adopted for the component or part. It is this co-ordination at the design stage that will yield optimum results to the system of buyer-supplier.

The purchasing of raw materials may be either done by ancillary units or by the major firm. In either case, objective criteria for testing and accepting raw materials should be the same and subject to the surveillence and approval of the major firm. The documentations should be necessary and relevant for quality assurance including acceptance/rejection/rectification status of lots with dates and sources indicated. In other words, purchasing function should have the procedures and clauses drawn up to ensure that the quality of raw materials are as required in the end-product programme of the major firm.

In the actual manufacture, buyer can indicate where checks for quality control are needed and where records are to be kept. The estimate of manufacturing capabilities (including machine tolerances plus the human skills) would be facilitated by these records kept— besides

providing a quality history that can be incorporated in that of the end-product.

The internal (supplier) inspection procedures should make full use of the Quality Control information received from manufacturing department. It would be an integrated quality control and inspection system, to ensure that what is passed on to the buyer has the full satisfaction of the *seller also* to meet *all* requirements of quality. The buyer will retain the essential requisite of an acceptance inspection by him : the buyer would devise appropriate acceptance sampling inspection to meet the quality assurance and reliability status—and these would be in addition to the quality assurance furnished by supplier's records, and perhaps even based on them. But the acceptance inspection by buyer is necessary and cannot be dispensed with though it can be modified and lessened (in quantity inspected) at necessary times and situations. However, the buyer's acceptance inspection serves only a supplementary purpose to the Quality Programme of the supplier and this must be appreciated by buyer and supplier. Too much reliance *only* on the buyer's acceptance sampling inspection, without the supporting quality control assurance records from the manufacturing department would weaken the confidence in the assurance attached to Quality and Reliability. So, it is imperative that the internal (supplier) inspection and quality control records are co-ordinated with the buyer's acceptance inspection—as an integrated system.

The inventory storage, packaging and shipping have *all* to be adequate to safe-guard the quality aspects. The buyer, till he receives and accepts the product, has to rely on the supplier to follow quality requirements essential to assure the requirements of the buyer's end-product.

Quality and Reliability based on data. Scope for Selective Assembly

Such an integrated system of operations of the supplier with the buyer's approval (and advice where necessary) would ensure records and data to estimate objectively quality aspects of the sub-contracted items : and these will facilitate quality assurance and reliability estimates of the end-product. The end-product has to perform as required and the whole programme of sub-contracting has always this requirement of end product in view.

Data reporting and Statistical Quality Control are vital elements in this assessment of Quality assurance and Reliability. Quality and costs are inter related but *not* necessarily with a high positive correlation. However value and benefit of quality assurance and reliability increases many times more than the costs incurred. S. Q. C. charts have information value and operational effectiveness with economy : they should be used much more widely in these programmes of Quality Assurance and Reliability of sub-contracted items. The buyer should ensure this so that he can have the benefit of quality assurance and reliability (which he seeks for the end-product) with considerably *less* problems and arguments with the supplier (ancillary) firms.

Also, procedures of Selective Assembly open many possibilities, if *standards* are maintained in the process and *data* is available to assess the Level of Quality (i. e. the mean) and the inherent variation (i. e. the standard deviation) of the process. Such information about process capability is a great aid in developing appropriate Selective Assembly procedures. The analysis and applications of Selective Assembly are very well discussed by Mansoor (1961).

The scope for application of selective assembly—especially in global organisation of facilities and skills—has to be examined to realise the mutual advantage of the buyer and seller. Many of the developing countries have the skills and equipments to maintain standard quality though in some cases the tolerances may be larger than stipulated. In these situations, using Selective Assembly methods, there would be excellent opportunities for optimization of results of global efforts—co-ordinated for the benefit of the buyer, seller and the final consumer. Desmond and Setty (1962) have indicated that "Selective assembly is used whenever the tolerances which have to be allowed for the components are so large that the natural build up with random assembly will not satisfy functional requirements." In devising methods of Selective assembly, considerable dependence is placed on the knowledge of all process capabilities, and also may involve as an essential need, a quality control programme to ensure that the mean size

produced for every component is the same as the objective mean. The role of S. Q. C. in this is obviously very important.

Though all *other* aspects discussed in this paper are relevant, necessary and beneficial, they will all increase in effectiveness *if* suitable S. Q. C. charts are used in manufacturing. Indian Industries have a growth potential when the buyer-supplier co-ordination as a system is developed more fully, and in this S. Q. C. charts have a vital role.

REFERENCES

1. *Calabro, S. R. : Reliability Principles and Practices.* New York : McGraw Hill, 1962.
2. Ekambaram, S. K. *The Statistical Basis of Quality Control Charts.* London : Asia Publishing House, 1966.
3. Shewhart, W. A. Economic Control of Quality of Manufactured Product. Princeton, N J. : D. Van Nostrand Company, Inc. 1931.
4. Grant, E. L *Statistical Quality Control.* Tokyo : McGraw Hill and Kogakusha Company Ltd.
5. Mansoor, E. M Selective Assembly—Its analysis and applications. *International Journal of Production Research* Vol. I, 1-1961.
6. Desmond, D. J. and Setty, C. A. Simplification of Selective Assembly. *International Journal of Production Research*, April, 1962.

Ensure Proper
Tax Deduction
from
Salaries

The Income-tax Act requires every person responsible for payment of salary to deduct tax at source at the prescribed rates and deposit the same to the credit of the Central Government immediately in the case of Government employees and within seven days in the case of other employees.

Default of the Employer Attracts :

i) Recovery of the entire amount of tax from him;

ii) Levy of interest and penalty; and also

iii) Prosecution which may lead to rigorous imprisonment and also fine.

Avoid Penal Action :

ENSURE that the tax deductible on salary has been correctly deducted and deposited into Governments account within the time.

ADJUST short deduction, if any, out of salary payments made in the month of February/ March, 1982.

Director of Inspection
(Research, Statistics & Public Relations)
INCOME-TAX DEPARTMENT
New Delhi-110001

davp 81/325

Productivity
1981, XXII, 3, 33-37

Determining Factor Weights in Job Evaluation by Linear Programming

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Job Evaluation is being increasingly used by managements to determine the relative worth of a job in comparison to another, so that each job can be assured a fair compensation. This paper describes the use of linear programming to determine a consistent weighting scheme in a job evaluation exercise of non-managerial technical staff in an organisation.

What is a fair wage for a particular job ? How much should a person doing a certain job be paid ? Of course, collective bargaining, wage agreements, labour laws, market supply and demand forces influence the wage structure, but management is still concerned about using systematic methods to remove inequities in rates on individual jobs. Market mechanisms alone cannot determine wage rates. Job evaluation schemes have now come to stay as a scientific and rational basis for placing jobs in appropriate wage/salary grades, so that each job can be assured a fair compensation consistent with its relative worth and management policy.

Job evaluation may be defined as a systematic means of measuring job content, and determining the value of an individual job in relation to the other jobs in the organisation. It begins with job analysis to obtain job descriptions and job specifications, and includes the process of relating the descriptions by some system designed to determine the relative value of the job or group of jobs. It provides the basis for comparison among jobs by explicit and precise recognition of factors described in the job specification, and the relative importance of each of the factors for the performance of each job. Jobs cant hen be rank ordered or graded, to be later used as a basis for a compensation system (otis et.al., 1954).

The rating schemes employed to determine job worth may be classified as non-quantitative as in the case of ranking methods and classification systems, or quantitative, such as point method or factor comparison systems. Non-quantitative

systems rate the job as a whole and end up with simple relative values. They do not indicate how much more valuable one job is as compared to another. Quantitative Schemes on the other hand, consider jobs to consist of several comparable factors, and establish numerical rating scales for different levels of each of these factors. The relative worth of a job is then measured by the total of numerical scores for the different factors. The difference in numerical scores indicates the difference in value between jobs.

While there is controversy over the relative superiority of the quantitative methods over the non-quantitative ones, quantitative methods are used more frequently as they are seen to reduce the rating biases of individuals. Further, by assigning monetary equivalents to each of the factors, which reflect the expected range and a weighting of their relative importance, a consistent scale of compensation can be introduced within an organization.

The problem of assigning proper weights to factors for reflecting their relative importance is often subject to criticism. The most commonly used approach to solve this weighting problem is through the use of "collective judgement" of several persons or, the "best guess". As any biases in selection of weights can invalidate the entire job evaluation exercise, any technique which minimises the subjectivity or judgement element in determining factor weights can substantially improve the process.

This paper describes an application of linear programming for determining suitable factor weights in a job evaluation exercise of non-managerial technical staff in an organization. Several such studies using linear programming for designing job evaluation and compensation schemes have been reported in the literature (Bruno, 1971, etc.).

Application of Linear Programming

The prevailing salary structure of an organization assumes an implicit weighting of factors, which are then being compensated for by the existing salary grades. By using linear programming, we try to determine a factor weighting system that minimises the discrepancy between factor ratings of jobs and their existing salary grades.

In the Point Method of job evaluation, a series of rating scales are constructed, one for each of the factors identified as important in the job. Each factor is divided into several degrees or levels, and points are assigned to these depending upon the relative importance of the factors. The differences among jobs are then reflected in the different values which are assigned to the various factors. It is these factor weights which are sought to be determined by linear programming.

Formulation of the LP Model

In the present study, four major compensable factors were defined, namely, Skill, Effort, Responsibility and Working conditions. Each of these factors was further sub-divided into several sub factors, in order to provide greater flexibility in evaluation of factor requirements in different jobs. These are described in Table 1. Each sub-factor was again divided into well defined levels or degrees. Key jobs were selected and their job descriptions prepared in consultation with the concerned heads of Department and supervisors. Using the factor descriptions and

Table 1

Major Compensable Factors

Major Factors	Sub-factors	Factor Number
Skill	(a) Education	1
	(b) Experience	2
	(c) Complexity	3
Effort	(a) Physical/mental	4
	(b) Reactions under extreme stress	5
	(c) Pressure of work	6
Responsibility	(a) Supervision	7
	(b) Confidential matters	8
	(c) Contacts	9
	(d) Materials/machinery/safety	10
Working conditions	(a) Work during exceptional hours	11
	(b) Surroundings/hazards/use of protective devices	12

degree definitions, each job was assigned an appropriate degree for each of the factors/sub-factors. These details are provided in Table-2 for the thirty key jobs selected.

Table 2

Levels of factors allocated to jobs

Job Number / Factor Number	1	2	3	4	5	6	7	8	9	10	11	12	Mid-points of salary scale
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	
1	2	2	1	2	1	3	1	1	1	1	1	2	450
2	3	3	2	3	1	3	1	1	1	1	2	2	785
3	3	4	3	4	2	3	1	1	2	1	2	1	1025
4	3	1	2	2	1	3	1	1	1	1	2	2	650
5	1	1	1	2	1	2	1	1	1	1	3	3	335
6	3	2	2	2	1	4	1	1	1	1	3	3	650
7	3	2	2	2	1	3	1	1	1	2	3	3	650
8	3	3	2	2	2	3	1	1	1	2	3	3	785
9	3	4	2	1	2	4	3	1	1	2	3	3	1260
10	1	1	1	2	1	3	1	1	1	1	2	2	335
11	3	3	2	3	1	3	1	1	1	1	1	1	650
12	3	1	2	2	2	3	1	1	1	1	2	2	650
13	2	2	2	2	1	2	1	1	1	2	1	1	450
14	4	2	3	3	2	4	1	2	1	2	2	2	1025
15	4	1	3	2	1	2	1	1	3	2	1	1	785
16	3	4	3	4	1	3	1	2	1	2	1	2	1025
17	4	3	3	3	2	3	1	2	1	2	2	2	1025
18	1	3	2	1	1	3	2	1	2	1	2	2	650
19	1	1	1	2	1	3	1	1	1	1	3	2	335
20	1	1	1	2	1	1	1	1	1	1	1	2	335
21	3	1	2	2	1	3	2	1	1	1	1	2	650
22	1	3	2	2	1	3	1	1	1	1	2	2	450
23	2	3	2	2	1	3	2	1	1	1	2	2	785
24	3	4	3	2	1	3	2	1	1	1	2	2	1260
25	2	3	2	2	1	3	1	1	1	1	2	2	650
26	1	1	1	2	1	3	2	1	1	1	3	2	335
27	3	4	3	2	2	3	2	1	1	1	2	3	1260
28	1	1	1	1	1	3	1	1	1	1	3	3	335
29	2	2	2	2	1	3	1	1	1	1	3	3	450
30	2	3	2	2	1	3	1	1	1	1	3	3	650

The following assumptions are made in formulating the model.

— The present compensation for each job would be determined by the mid-point of the present salary scale.

— Distribution of monetary value to each of the degrees of the different factors/ sub-factors would follow an arithmetic progression.

— Since the weighting system need not completely explain the present compensation structure, the deviation between the total evaluation and an existing salary may be either negative or positive, implying thereby that the job is either under or over compensated. Our objective would be the minimisation of the sum of these deviations.

— Each major factor should have an upper and lower limit on the weightage given to it. Also, every sub-factor must have a minimum weightage. This is to ensure that no factor dominates the evaluation structure, and every sub-factor is given some weightage.

We define

a_{ij} = the degree level allocated to i^{th} job for J^{th} factor.

X_j = weightage allocated to the first degree of the jth factor.

b_i = mid point of the existing pay scale of the ith job.

d_i^- = negative deviation between the total evaluation and the mid point of the existing pay scale of the ith job.

d_i^+ = positive deviation between the total evaluation and the mid point of the existing pay scale of the ith job.

Our model may then be stated as follows :

$$\text{Minimize } ; \sum_{i=1}^{30} (d_i^- + d_i^+)$$

Subject to

$$\sum_{j=1}^{12} a_{ij} X_j + d_i^- - d_i^+ = b_i \qquad i = 1, 2, \ldots 30$$

$$0{,}2 \leqslant \frac{X_1 + X_2 + X_3}{\sum_{j=1}^{12} X_j} \leqslant 0.6$$

$$0.1 \leqslant \frac{X_4 + X_5 + X_6}{\sum_{j=1}^{12} X_j} \leqslant 0.4$$

$$0.1 \leqslant \frac{X_7 + X_8 + X_9 + X_{10}}{\sum_{j=1}^{12} X_j} \leqslant 0.4$$

$$0.05 \leqslant \frac{X_{11} + X_{42}}{\sum_{j=1}^{12} X_j} \leqslant 0.2$$

and

$$\frac{X_j}{\sum_{j=1}^{12} X_j} \leqslant 0.02 \qquad j = 1, 2, \ldots 12$$

$$X_j \geqslant 0 \qquad j = 1, 2, \ldots 12$$

Results and Discussion

The above linear programming problem with 72 variables (12 factors, 60 deviational variables) and 50 constraints was solved on a PDP-11/70 computer. We find from the solution that the "skill" factor emerges as the dominating factor, and the "working conditions" factor receives the smallest weightage. The weightages

allocated to each of the factors are provided in Table-3.

Table 3

Weightage of Each Factor

Factor Number	Faclors	Percent Weightage of factor
1	Education	27.3
2	Experience	17.8
3	Complexity	14.9
4	Physical/mental effort	2.0
5	Reactions under extreme stress	6.0
6	Pressure of work	2.0
7	Supervision	19.0
8	Confidential matters	2.0
9	Contacts	2.0
10	Materials/machinery/safety	2.0
11	Work during exceptional hours	2.0
12	Surroundings/hazards/use of protective device	3.0

When this weighting scheme is used, the compensation for twenty out of the thirty jobs turned out to be in their existing salary grades with marginal deviation from the mid-point of the existing salary grade. The compensation for the remaining ten jobs was also in their existing salary grade, but with substantial deviation from the mid-point. Six out of these ten jobs were under compensated, whereas four were over-compensated.

It is clear from Table-3 that some factors are relatively more important than others. However, this will depend upon the constraints on factor weights which are incorporated in the linear programming model. By using relatively weak constraints, we can obtain guidelines on factor importance (Rehmus et.el., 1963). Furthermore, greater effort can then be devoted to defining factor degrees so that jobs can be better differentiated in terms of their requirements of these factors.

The compensation scheme of an organization is always influenced by external market conditions. It is for this reason that we have used the mid-points of existing salary grades to define the current compensation relationship between the jobs. The factor weights obtained by linear programming help in minimising the internal inequality between the compensation of various jobs. This is a major advantage, because employees are always concerned about internal salary relationships.

REFERENCES

1. Bruno, J.E., Compensation of School District Personnel, *Management Science*, Vol. 17, No. 10, 1971, pp 569-587.
2. Charnes, A. Cooper, W.W. and FERGUSON, R.O., Optimal Estimation of Executive Compensation by Linear Programming. *Management Science*, Vol. 1, No. 2, 1955, Pp 138-151.
3. Fabozzi, F. J. and Daddio R., A Linear Programming Salary Evaluation Model for High School Personnel, *Operational Research Quarterly*, Vol. 28, No. 2, 1977, Pp 401-413.
4. Otis, J. L. ; and Leukart, R. H., *Job Evaluation*, Englewood Cliffs M.J., : Prentice-Hall, Inc., 1954.
5. Narayana, M.V., Supervisory Job Evaluation Scheme—A Linear Programming Approach. *Industrial Engineering & Management*, Vol. 4, Nos. 3 & 4, 1969, Pp. 51-54.
6. Patel, K. and Misdra, R., Designing Job Evaluation Scheme by LP, *Proceedings of XIIIth Annual Convention of O.R. Soclety of India, Feb. 19-21*, 1981, Pp. 2-9.
7. Rehmus, F. P. and Wagner, H. M., Applying Linear Programming to Your Pay Structure, *Business Horizons*, Vol. 6, No. 4, Winter 1963, Pp. 89-98.

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Choice of Parameters in Dodge's Continuous Sampling Plan

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An optimal choice among several continuous sampling plans suggested by Dodge ensuring the same specified AOQL value can be attempted by applying different criteria for optimal decisions in the face of uncertainity to the pay-off matrix. Primarily a methodological study, the paper indicates possibilities for further work in this area.

Despite several limitations, the Dodge Plan (Continuous Sampling Plan-I) continues to be an acceptable rectifying plan for inspection from continuous production. This plan is characterised by two parameters, viz. f.—the sampling fraction and i—the length of a sequence of non-defective items whose occurrence initiates a change from complete to sampling inspection. Dodge has worked out the AOQL (Average Outgoing Quality Level) of this plan on the assumption of a state of statistical control. He has provided a graph from which combinations of f and i ensuring the same AOQL can be read out for a wide range of AOQL values.

Unlike sampling inspection plans by Dodge and Romig (1959) available for lot-by-lot sampling, the Dodge plan for continuous production does not provide a cost protection to the producer by minimising the average fraction inspected (AFI). This, incidentally, makes it difficult to choose a particular plan (with specified values of f and i) for any stipulated AOQL value. In fact, Dodge did not provide any method for selecting one out of several plans for which the value of AOQL is the same.

The object of this paper is to apply different criteria for optimal decisions in the face of uncertainty to choose a sampling plan for a specified AOQL which will take care of the average fraction inspected. For this purpose a pay-off matrix has been constructed with different values of process fraction defective (p) defining possible states of nature, different combinations of f and i values for a specified AOQL as feasible strategies and

average fraction inspected as pay-off. The consideration of varying process fraction defective is justified because of the usual absence of knowledge about the process fraction defective. A stronger support is derived from the findings of Mood (1943) that sampling inspection makes sense only when the process fraction defective shows random variations.

As expected, different optimality criteria lead to the selection of different sampling plans. However, these choices are not widely different from each other.

Criteria for Optimal Decisions in the Face of Uncertainty

In situations where probabilities of different states of nature being realised are not known, the following four criteria to select the optimal strategy are generally employed :

For a given ACQL, let there be w possible combinations of f and i the k th combination being denoted by A_k. Let I_{ks} be the AFI for A_k when $p = p_s$ (s=1, 2,...d). While the process fraction defective p really varies continuously from 0 to 1 and more rationally over a narrower range, say, p_1 to p_2, $0<p_1<p_2<1$, we may assume several discrete values of p. For example, we may take eleven possible values of p ranging from 0 to 0.1 at equal intervals of 0.01. since it is rather meaningless to consider values of p beyond 0.1 while considering plans for AOQL values like 0.02, 0.05 and 0.10.

(i) Laplace criterion :

According to this criterion, the strategy A_r is selected if

$$\bar{I}_r = \sum_{S=1}^{d} I_{rs} / d \text{ is a minimum}$$

$$\text{among } \bar{I}_k = \sum_{S} I_{ks} / d \quad k=1,2, \ldots w.$$

(ii) Wald's Minimax Criterion :

According to this criterion, which is also known as the criterion of pessimism, the combination A_1 is recommended if

$$\underset{k}{\text{Min}} \; \underset{s}{\text{Max}} \; I_{ks} = \underset{s}{\text{Max}} \; I_{1s}$$

(iii) Savage's Regret criterion :

This criterion, argues that there exists at least one minimum I_{ks} for each p_s. If it is known that the process fraction defective where $p=p_s$, the decison-maker's best course of action could be to choose A_m such that

$$I_{ms} = \text{Min } I_{ks},$$

The choice of any other combination results in some amount of regret, the measure of regret for A_k being

$$R_{ks} = I_{ks} - I_{ms}$$

It is then possible to construct the regret matrix with elements R_{ks} and apply Wald's minimax criterion to determine the optimal combination (i, f). The combination A_n is recommended

$$\text{if } \text{Min}_k \; \text{Max}_s \; R_{ks} = \text{Max}_s \; R_{ns}$$

(iv) Hurwicz Criterion :

This criterion (1951) would consider the minimum (m_k) and the maximum M_k values of AFI for each A_k and assign the index

$$H_k = \alpha \, m_k + (1-\alpha) \, M_k$$

to it. Here α ($0 \leqslant \alpha \leqslant 1$) is called the coefficient of optimism.

The Hurwicz criterion recommends the combination A_p if

$$H_p = \underset{k}{\text{Min}} \; H^k.$$

The Pay-off Matrix

The expression for AFI corresponding to a plan with parameters f and i is as follows

$$\text{AFI} = \frac{1}{1+(n-1)\,q^i}$$

where $n=1/f$ and $q=1-p$.

Values of AFI for p=0.01 to 0.10 at intervals of 0.01 have been calculated for all the strategies or (f,i) combinations which could be read off from the chart given by Dodge corresponding to AOQL = 0.02, 0.05 and 0.10. The strategies were arranged according to increasing values of i (and consequently in the decreasing order of magnitude for f.)

In each row of the pay-off matrix corresponding to a given strategy the AFI values increase monotonically with p. Consequently, the maximum AFI for each plan (strategy) in the pay-off matrix corresponds to p=0.10.

The behaviour of AFI values over different strategies for the same value of p has not been consistent. For low values of p, AFI values for the same p are found to be decreasing monotonically as i increases, so that the minimum AFI corresponds to a plan with the highest i (and as such the lowest f). However, this picture does not remain valid for each p. In fact, for a lower value of AOQL, a change in the columnurse behaviour of AFI values is observed at an earlier value of p. For example, when AOQL=0.02, the minimum AFI corresponds to the plan with the lowest f for values of p$\leqslant$0.04. When p=0.05 the minimum AFI corresponds to the plan i=28 and f=0.25. AFI values increase on both sides of this particular value of f, although the increase is much slower for values of f lower than 0.25. However, it must be pointed out that AFI values in a column exhibit a number of local maxima and local minima. In fact, it is this irregular behaviour of AFI values that really calls for some decision criteria for choosing the optimal plans.

4 Optimal (f, i) Combinations

An application of minimax criterion leads to the choice of plans which are worse than plans considered to be optimal by an application of Laplace criterion in the sense of requiring a smaller i (and correspondingly a larger f) for each of the AOQL values namely 0.02, 0.05 and 0.10. With an increase in AOQL, the value of i increases monotonically in plans declared as optimal by the minimax criterion. Resulting maximum AFI values diminish monotonically as is expected with less and less stringent quality requirement. However, in the set of plans found to be optimal according to the Laplace criterion, although the expected AFI diminishes monotoni-

Table 1

Optimal Plans for different AOQL values using different decision criteria.

CRITERION	AOQL= 0.02	AOQL= 0.05	AOQL= 0.10
1. Minimax	(14.485) AFI=.8045579	(7, .14) AFI=.4968426	(23, .012) AFI=.1205584
2. Laplace	(28, .250) E(AFI)=.60438435	(40, .021) E(AFI=.225?7195	(25, .050) E(AFI=.05114059
3. Savage	(i) 0 .105 (14, .485) (ii) .105 .296 (19, .375) (iii) .296 .334 (28, .250) (iv) .334 1.0 130, .010)	(33, .037)	(25, .010)
4. Hurwicz	i) 0 .046 (17, .140) ii) .046 .656 (28, .050) iii) .656 .865 (40, .021) iv) .865 1.0 (50, 010)	(i) 0 .558 (23, .012) (ii) .558 .01 (25, .010)	

cally with increasing p, the plan parameters do not follow a definite pattern. In fact, the parameter combinations for optimal plans corresponding to AOQL = 0.02, 0.05 and 0.10 are respectively (28, .250), (40, .021) and (25, .010). The sampling fraction however, diminishes monotonically with increasing AOQL in all the four criterion cases. The use of Savage criterion results in optimal plans which are almost as good as those corresponding to the Laplace criterion. In fact, both these criteria lead to the same optimal choice namely (25, .010) for AOQL = 0.10.

Since the number of feasible strategies for each AOQL value was very large, it was difficult to apply the Hurwicz criterion. For this, possible dominance of some rows in the pay-off matrix over others was examined to delete dominated rows. In cases where even the number of dominant rows were considerable, piece-wise dominance over different ranges of the coefficient of optimism (α) was examined. In fact, an examination of this piece-wise dominance greatly reduced the number of strategies to be considered (separately) over each range of α values. For the admissible strategies straight lines showing variations in the expected AFI for variations in α intersect one another. For different ranges of α values different straight lines will have the minimum ordinate and hence different strategies will be optimal.

An application of the Hurwicz criterion results in a wider set of optimum sampling plans for a smaller AOQL value. For AOQL = 0.10, the plan (23, .012) works out as optimal for the range $0 \leqslant \alpha \leqslant 0.558$, while beyond this range the plan (25, .010) comes out to be optimal. Thus a pessimist corroborates the minimax choice, while an optimist has a choice supported by both the Laplace and the Savage criteria. In fact, for this AOQL value viz 0.10, the combinations (23, 0.12) and (25, 0.10) come out to be the optimal plans.

As expected the minimax choice coincides with the optimal plan according to the Hurwicz criterion for low values of α. In fact, these two choices are identical over the range $0 \leqslant \alpha \leqslant 0.105$ in case of AOQL = 0.02 and over the range $0 \leqslant \alpha \leqslant 0.046$ in the case of AOQL = 0.05. For AOQL = 0.02, the plan (130, .010) comes out to be optimal over the widest range of α values, namely 0.334 to 1.0, while in the case of AOQL = 0.05, the plan (28, .050) remains optimal over the range 0.046 to 0.656. The Laplace choice is supported over a very narrow range of α values both for AOQL = 0.02 and for AOQL = 0.05.

It is quite possible to assume a prior distribution for the process fraction defective and to apply criteria for optimal decisions under risk. In fact this has been taken up by the authors, considering the minimum expected AFI criterion, expectation being taken over a variety of prior distributions. It is also useful to consider as pay–off the 'average excess cost' due to lack of knowledge about the true fraction defective in the process to take into account relevant costs and reach an economically optimum continuous sampling plan from among those ensuring a specified AOQL. The optimal parameter combinations pointed out in this paper are more or less illustrative of the methods involved, rather than definite choices for applications in practice. While the same set of p values has been used for all the AOQL values chosen, it is only proper to allow the set to depend on the chosen AOQL value.

REFERENCES

1. Anscombe, F. J. Rectifying inspection of a continuous output, *J. Amer Statist Assoc.*, 53, 1958, 702-719.
2. Dey, B. R.—Ph. D. disertation submitted to the Calcutta University, 1978.
3. Dodge, H. F. A Sampling inspection plan for continuous production. *Ann. Math. Statistics*, 14, 1943, 264-79.
4. Dodge, H. F. and Romig, H. G. *Sampling Inspection Tables. Single and Double Sampling*, 2nd Edn. New York: John Wiley, 1959.
5. Hurwicz, L. Optimality criteria for decision making under ignorance. Cowless Commission Discussion Paper, Statistics, No. 370 (mimeographed), 1951.
6. Mood, A. M. On the dependence of sampling inspection plans upon population distributions, *Ann. Math. Statistics*, 14, 1943, 415-25.

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Choice of Exhaustible Energy Resources —A Control Theory Approach

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The paper presents a model for the study of optimality in a large, dynamic interfuel substitution system. Given a set of energy resources, costs for their extraction and energy conversion technologies and bounds on rate of conversion to alternative fuels, the model generates families of dynamic resource allocations that minimize the discounted cost of energy production over a given planning horizon.

With coal reserves of the order of 100 billion tonnes, oil 400 million tonnes and a hydro-power potential of 42 million kilowatts, India is richly endowed with energy resources. But the trend of our resource utilization is very much constrained by the availability factors sustaining future growth. Low resource extraction rates and continuing dependence on import of oils indicate that the supply of either of the fuel resources is likely to be far behind the future demand figures which itself are biased and influenced by past-constrained-trends of energy consumption.

On the other hand, the current energy situation, accented by the past shortages of the Arab Oil embargo, has sharply emphasized the need for rational use of fuel resources. Beyond the immediate problems of allocation of today's scarce resources, the concern is of long-range planning for the satisfaction of anticipated energy demands. Alongside conservation of resources by curtailing demands, there is a need to balance the alternative uses of the resources as fuels and as raw materials. All such considerations lead to the question of how to optimally develop our energy resources, overtime, for their proper utilization to meet the evergrowing energy demands.

Problems with Long Range Planning

Inspite of the fact that energy system studies are currently growing at an explosive rate, there is still a need for current energy data, descriptions of current modelling efforts and information on current energy technology.

A global energy problem whose objectives become multi-dimensional, conflicting and complicated with ill-defined constraints appears impossible to tackle. Moreover, a set of difficulties in long range planning, as listed by Linstone (1974), and the unlike precedences observed by Coates (1973) can be associated with the energy policy models categorizing them identical to the 'wicked systems' of Liebman (1975) with decision making problems without having a common agreement on goals. Under such situations, where it becomes impossible to control a large system perfectly, a model needs to be simple enough to be understood. Further, it is more realistic to expect that the description of a quantitative optimal solution would help establish which energy resources are most critical from the type of the methodology adopted. The following analysis presents a control theory approach model for the study of optimality in a large dynamic interfuel substitution system.

Existing Energy Models

According to modeling methodology some optimizing energy models can be described by Linear Programs (Hadley, 1962). But many practical cases of interest, however, can not be modeled taking linear functions as they may suffer from complexity and difficulty in interpretation when translated into a linear programme. To describe the direct and indirect effect on economy resulting from energy policy changes, a special class of linear models i. e. Input/Output models or Leontief Models (1966), are imbedded in some econometric energy models. This simple but effective analysis with interstage linking constraints successfully deals with the dynamic system but is, however, limited by the restrictions inherent in linear models. Two other special structure linear programmes "Transportation Problems" and "Network Flows" have been widely used in energy modeling but suffer with their specific applications. Moreover, it is noteworthy that the data base for such models is a project in itself.

Other models that merit mention are—A model emphasizing one sector of energy system developed by Battelle Pacific Northwest Laboratories (Fisher & Kaysen 1964), model dealing with alternative strategies for all fuels and conducted at Brookhaven National Laboratories started as a static model and then extended to dynamic problems (Hoffman, 1972, 73), and the project independence linear programming model. Nordhouse (1973) constructed a worldwide linear programming model for energy resources allocation minimizing the cost of meeting an exogeneous demand. Dynamic energy system models as typified by Banghman (1972) are complimented by Deonigi's supply models (1970).

Scope and Objectives

Retreating from the problem of finiteness and unpredictability of technology in the distant future, the analysis considers alternatives resulting in a problem of medium range planning for the satisfaction of judicious energy demands. Demands are met by interfuel substitution considering all those constraints imposed by nature and technology. Energy resources with their total consumption including non-energy uses, are characterized by extraction costs which rise with cumulative consumption, and resource exhaustability is expressed by unbounded extraction costs. Cost functions for resources are assumed dependent, in general, on cumulative consumption, time and extraction rate. The objective is to develop a methodology for minimization of total discounted extraction and substitution costs over a medium range planning horizon while meeting a given range planning unbiased demand schedule. The qualifying fuel consumption rates and thus the resulting optimal resource consumptions generate the policies for conserving or developing a particular energy resource depending on a subjective weightage given to that resource category.

Defining the problem framework

Given a set of energy resources and a set of utilization categories where each category has similar substitution possibilities and expense, the demand rates for each utilization category are to be met by one or more resources. Substitution costs for each demand category account for the penalty for not using the cheapest fuel and may be taken a function of time and technological factors. In order to limit the changeover rates to alternative fuels or to give sufficient allowance to adopt the technological changes, if applicable, the upper and lower limits of consumption rates are defined as a function of time. Efficiency factors may be considered time dependent which accounts for the losses associated as a fraction of raw resource available for its end use. Dynamic

resources extraction cost functions provide the preference level to use a particular resource. Leaving aside the factors of competitive pricing mechanism, the total discounted costs incurred in meeting the given exogeneous demands over a planning horizon are summed into the objective function to be minimized. The objective may be expressed as :

$$\text{Min} \int_{o}^{T-\alpha} e\Sigma_{ij} \left\{ c_i\,(x_i\,(t), \Sigma_j u_{ij}(t),\, t) + p_{ij}(u_{ij}(t),\, t) \right\} u_{ij}\,(t)\, dt$$

Where $u_{ij}\,(t)$ = Consumption rate of resource i by utilization class j at time t.

$x_i\,(t)$ = Cumulative consumption rate of resource i at time ti.

$c_i\,(x_i\,(t), \Sigma_j u_{ij}\,(t), t)$ = Per unit extraction cost for resource i at time ti, it is a known function of $X_i\,(t)$, $X_i\,(t)$ and t.

$p_{ij}\,(u_{ij}\,(t), t)$ = Per unit substitution costs or penalty to use resource i by utilization class j at time ti, a given function of $u_{ij}\,(t)$ and t.

= time discount rate.

T = Planning time horizon

The model constraints may be defined as

$$\Sigma_i e\,(t)\, u_{ij}\,(t) = d_j\,(t) \qquad \forall\, j \qquad (i)$$

$$x_i(t) = \int_{o}^{t} \Sigma_j u_{ij}\,(t) \qquad \forall\, i \qquad (ii)$$

$$u_{ij}^{-}\,(t) \leqslant u_{ij}\,(t) \leqslant u_{ij}^{+} \qquad \forall\, ij \qquad (iii)$$

$$u_{ij}\,(t) \geqslant o \qquad \forall\, ij \qquad (iv)$$

Where

$e_{ij}(t)$ = Efficiency in using resource i for demanded sector j at time t

$d_j\,(t)$ = Demand of utilization sector j at time t.

$x_i\,(t)$ = Rate of collective consumption of resource i by all the demand sectors at that time t.

$u_{ij}^{-}\,(t)$ = Lower bound of rate of change of consumption of resource i by utilization sector j at time t.

$u_{ij}^{+}(t)$ Upper bound of rate of change of consumption of resource i by utilization sector j at time t.

Equation (i) denotes the demand constraint making the sum of the consumption rates for each resource equal to the given utilization sector demand for a given efficiency factor in using fuel i for demand sector j. Cumulative consumption of resource i, obtained by integrating the sum of the consumption rates over all utilization sectors j are given by equation (ii). Constraints in equation (iii) bounds the rate of change of the consumption rates within the upper and lower bounds for the rate of conversion to alternative energy sources. Last equation is non-negative consumption constraint.

Solution approach

In order to generate the families of dynamic resource allocations that minimize the discounted cost of energy production over a given planning horizon and also to examine, by some subjective judgement, the effect of such resulting alternatives, a choice of a proper approach is essential. The real energy system is continuous in time. For systems in continuum, the analysis is very much approachable by generating the finite difference equations to approximate the continuous system and Pontryagin's maximum principle may be considered as a control theory formulation of a calculus of such class problems. Very well suited to most variation problems this principle has a distinction that obtains results for a closed feasible control domain and attacks the problem of minimizing an integral objective function of state x and control variable u. The general formulation is of the form :

$$\text{Min} \int_{o}^{T} f(x,\, u,\, t)\, dt$$

Subject to

$x = g(x, u, t)$

$u \varepsilon U$

This expresses the evolution of the state variable as a function of control variables. The applied control theory views control constraints as a subset U of Euclidean space such that :

$$u(t) \varepsilon U \qquad \forall t \qquad (v)$$

The constraint of original problem in equation (iii) contains multidimensional variable u with inequality understood in the element wise sense. For application there is no loss of generality if this constraint is replaced by :

$$a(t_1-t_2) \leqslant u(t_1)-u(t_2) \leqslant b(t_1-t_2) \qquad (vi)$$

for all t_1 and t_2 contained in any subinterval of (o, t). Here a and b are the constants as in generalized Lipschitz condition with different "up and down" rate bounds respectively. The state equation may be generated from the equation (ii) as :

$$x_i(t) = \Sigma_j u_{ij}(t) \; \forall_i \qquad (vii)$$

In a general problem, there exists a constant λ o equal to o or—1 and an "adjoint vector $\lambda(t)$ with the dimension of x (t) which satisfy that the minimizing control u(t) maximizes the Hamiltonian H over the feasible set (t) where

$$H = \lambda_o \, f(x, u. t) + \lambda^1 \, g(x, u, t) \qquad (viii)$$

and, the adjoint vector obeys

$$\lambda_i = -\lambda_o \frac{\partial f}{\partial x_i} - \frac{\partial g}{\partial x_i} \qquad (ix)$$

When λ_o and λ^1 are not simultaneously zero.

Thus the Hamiltonian and Adjoint equations for the problem takes the shape.

1. When $\lambda_o = -1$

$$H = -e^{\alpha t} \Sigma_{ij} \, (c_i(X_i(t), \Sigma_j \mu_{ij}(t), t) + p_{ij}(\mu_{ij}(t), t)).$$

$$\mu_{ij}(t) + \Sigma_{ij} \lambda_i(t) \mu_{ij}(t) \qquad (x)$$

$$\lambda_i(t) = e^{-\alpha t}$$

$$\left[\frac{\partial c_i(x_i(t), \Sigma_j \mu_{ij}(t), t)}{\partial x_i(t)} + \frac{\partial p_{ij}(\mu_{ij}(t), t)}{\partial x_i}\right] \Sigma_j \mu_{ij}(t) \qquad (xi)$$

2. In the event $\lambda_o = O$, the adjoint obeys $\lambda^o(t) = O$ and $\lambda(t)$ is a constant vector. Thus, Hamiltonian is the linear combination.

$$\Sigma_{ij} \, \lambda_i(t) \, \mu_{ij}(t)$$

Solution Algorithm

Algorithm is based on the "Shooting Method" described by McCausefand.

A set of values assumed for the adjoint vector λ_i (o), the system equations are integrated forward in the time starting at the initial values, selecting the control μ_{ij} (t) at each time step so as to maximize the Hamiltonian. Because the Hamiltonian is linear in U and with only one equality constraints of demand values, it will exhibit a "pang-bang" control law—all but one elements of u will increase or decrease at maximum rate admissible. If $\triangle t$ denotes the time decretization interval between any two successive integrations such that

$$\triangle t = (t_{n+1} - t_n) \qquad (xii)$$

Where n denotes n^{th} interval,

then, steps of algorithm are defined as :

1. Select the initial adjoint values and set the states variables and control parameter at the beginning of the planning horizon at t=o and initialize the dynamic values for starting time, as

$$x_i(o) = X_i \qquad (xiii)$$

$$u_{ij}(o) = U_{ij} => \bar{\mu_{ij}}(o) \qquad (ivx)$$

$$\text{Discounted cost (D. C.)} = o \quad \text{for } n = 0 \qquad (xv)$$

2. Update the state values summing up the time interval times of consumption rates. Integrate forward the values of adjoint sets as per equation per λ_i (t), thus

$$\chi_i(t_{n+1}) = \chi_i(t_n) + (\triangle t)\Sigma_j \, \mu_{ij}(t_n) \text{ and } \lambda_i(t_{n+1}) = \lambda_i(t_n) + (\triangle t) e^{-\alpha t_n} \left[\left\{ \frac{(\partial C(x_i(t), {}_j \, u_{ij}(t),}{\partial x_i} \right\} + \frac{\partial p_{ij}(u_{ij}(t), t)}{\partial x_i} \right] \Sigma_j \, u_{ij}(t_n)) \qquad (xvi).$$

3. Solve the L. P. to obtain the optimal value of control variable μ (t_{n+1}) by

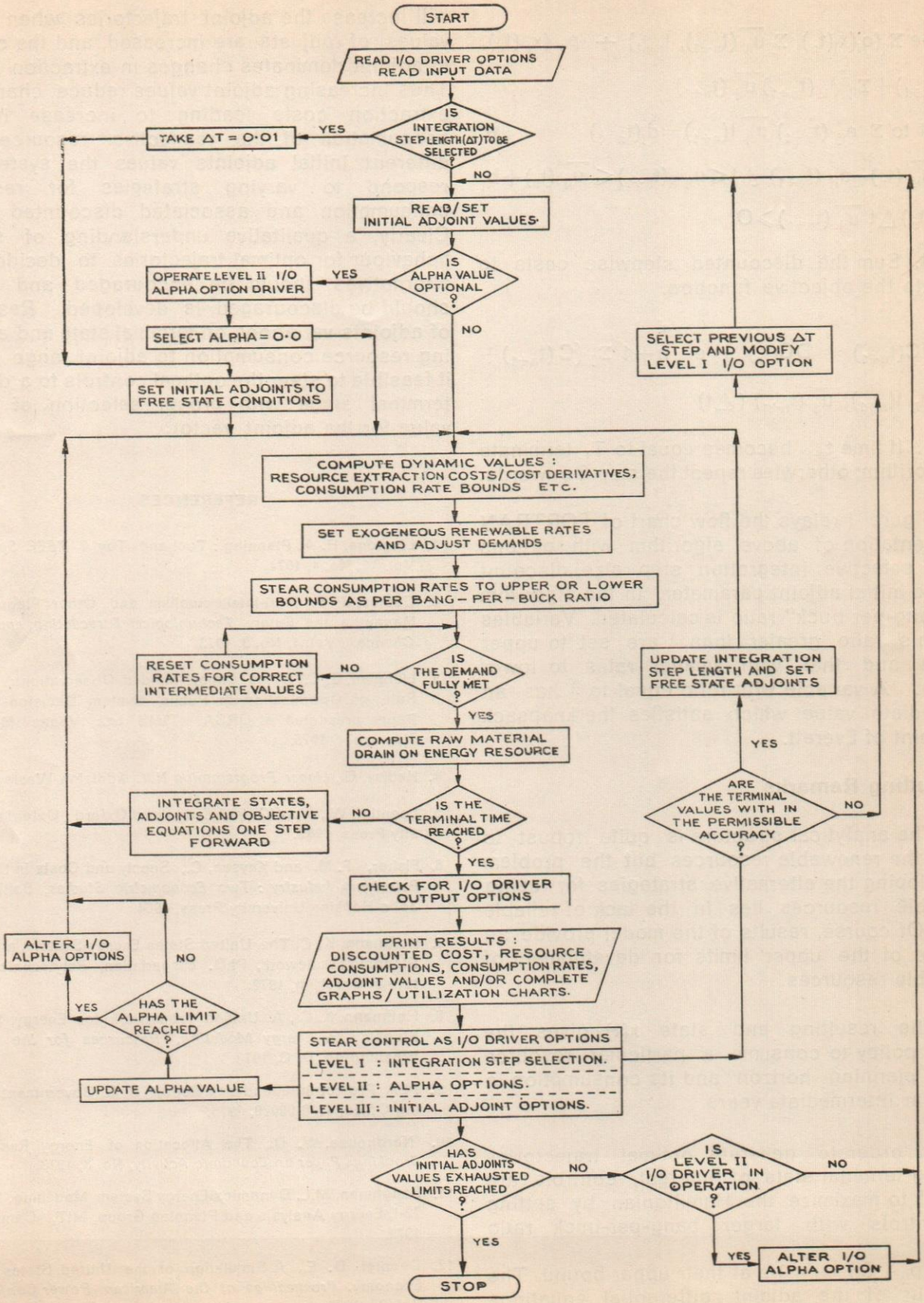
START
READ I/O DRIVER OPTIONS
READ INPUT DATA
IS INTEGRATION STEP LENGTH (ΔT) TO BE SELECTED ?
YES
TAKE ΔT = 0·01
NO
READ/SET INITIAL ADJOINT VALUES
IS ALPHA VALUE OPTIONAL ?
YES
OPERATE LEVEL II I/O ALPHA OPTION DRIVER
SELECT ALPHA = 0·0
NO
SET INITIAL ADJOINTS TO FREE STATE CONDITIONS
SELECT PREVIOUS ΔT STEP AND MODIFY LEVEL I I/O OPTION
COMPUTE DYNAMIC VALUES : RESOURCE EXTRACTION COSTS/COST DERIVATIVES, CONSUMPTION RATE BOUNDS ETC.
SET EXOGENEOUS RENEWABLE RATES AND ADJUST DEMANDS
STEAR CONSUMPTION RATES TO UPPER OR LOWER BOUNDS AS PER BANG – PER – BUCK RATIO
IS THE DEMAND FULLY MET ?
NO
RESET CONSUMPTION RATES FOR CORRECT INTERMEDIATE VALUES
YES
UPDATE INTEGRATION STEP LENGTH AND SET FREE STATE ADJOINTS
COMPUTE RAW MATERIAL DRAIN ON ENERGY RESOURCE
YES
ARE THE TERMINAL VALUES WITH IN THE PERMISSIBLE ACCURACY ?
NO
IS THE TERMINAL TIME REACHED ?
NO
INTEGRATE STATES, ADJOINTS AND OBJECTIVE EQUATIONS ONE STEP FORWARD
YES
CHECK FOR I/O DRIVER OUTPUT OPTIONS
PRINT RESULTS : DISCOUNTED COST, RESOURCE CONSUMPTIONS, CONSUMPTION RATES, ADJOINT VALUES AND/OR COMPLETE GRAPHS/UTILIZATION CHARTS.
ALTER I/O ALPHA OPTIONS
NO
HAS THE ALPHA LIMIT REACHED ?
YES
UPDATE ALPHA VALUE
STEAR CONTROL AS I/O DRIVER OPTIONS
LEVEL I : INTEGRATION STEP SELECTION.
LEVEL II : ALPHA OPTIONS.
LEVEL III : INITIAL ADJOINT OPTIONS.
HAS INITIAL ADJOINTS VALUES EXHAUSTED LIMITS REACHED ?
NO
IS LEVEL II I/O DRIVER IN OPERATION ?
NO
YES
ALTER I/O ALPHA OPTION
YES
STOP

Fig. 1

$$\text{Max.} \; -e^{-\alpha t} \Sigma_{ij}(o_i(x_i(t_n), \Sigma_j \overline{u_{ij}}(t_{n+1}), t_{n+1}) + p_{ij}(x_i(t_n), t_{n+1}) + \Sigma_{ij} \lambda_i(t_{n+1}) \overline{u_{ij}}(t_{n+1})$$

$$\text{Subject to } \Sigma_i e_{ij}(t_{n+1}) \overline{u_{ij}} t(_{n+1}) = d_j(t_{n+1}) \quad \forall$$

$$\overline{u_{ij}}(t_n) - a_{ij}(t_{n+1}) \triangle t \leqslant u_{ij}(t_{n+1}) \leqslant \overline{u_{ij}}(t_n) + b_i(t_n) \triangle t \, \overline{u_{ij}}(t_{n+1}) \geqslant 0$$

4. Sum the discounted stepwise costs to total into the objective function.

$$DC(t_{n+1}) = DC(t_n) + e^{-\alpha t}{}_{n+1} \Sigma_{ij} \{C_i(t_{n+1}) + p_{ij} t(_{n+1})\} \overline{u_{ij}}(t_{n+1}) (\triangle t)$$

5. If time t_{n+1} becomes equal to T, terminate the algorithm; otherwise repeat the step 2 onwards.

Figure I relays the flow chart of FORTRAN Implementation of above algorithm with options having selective integration step size, discount rate and initial adjoint parameter. In the algorithm the "bang-per buck" ratio is calculated. Variables with this ratio greater than λ are set to upper bounds and that with smaller rates to lower bounds. A variable with ratio equal to λ has an intermediate value which satisfies the knapsack constraint of Everett.

Concluding Remarks

The analytical structure is quite robust to handle the renewable resources but the problem in developing the alternative strategies for using renewable resources lies in the lack of reliable data. Of course, results of the model provide an estimate of the upper limits for development of renewable resources.

The resulting end state x(t) gives the optimal policy to consume a particular resource in the planning horizon and its consumption in particular intermediate years.

In order to generate optimal trajectories reaching terminal state of interest, controls are selected to maximize the Hamiltonian by setting the controls with larger bang-per-buck ratio $(-e^{-\alpha t}(p_{ij} + C_i) + \lambda)/e$ at their upper bound. The behaviour of the adjoint differential equations will increase the adjoint trajectories when initial values of adjusts are increased, and the change in adjoint dominates changes in extraction costs. Thus increasing adjoint values reduce change in extraction costs leading to increase in the consumption of the respective resource. For different initial adjoints values the system will respond to varying strategies for resource consumption and associated discounted costs. Clearly, a qualitative understanding of system behaviour for optimal trajectories to decide with alternatives should be encouraged and which should be discouraged, is developed. Response of adjoints variations on terminal state and analysing resource consumption to adjoint range makes it feasible to steer the optimal controls to a desired terminal stage with proper selection of initial value for the adjoint vector.

REFERENCES

1. Linstone, H. A. Planning : Tool and Toy ? *TEEE Spectrum*, Vol. 11, No. 4, 1974.
2. Coates, J. F. Anti-Intellectualism and Other Plagues on Managing the Future *Technological Forecasting and Social Change*. Vol. 4, No. 3, 1973.
3. Liebman, J. C. Some Simple-Minded Observations on the Role of Optimization in Public System Decision-Making Paper presented at ORSA. TIMS Las Vegas Meeting, November, 1975.
4. Hadley, G., *Linear Programming* N.Y. Addision-Wesley, 1962.
5. Leontief, W., *Input/Output Economics* Oxford : Oxford University Press, 1966.
6. Fisher, F. M. and Kaysen, C., Supply and Costs in the U.S. *Petroleum Industry : Two Econometric Studies*, Baltimore : John Hopkins University Press, 1964.
7. Hoffmann, K. C. The United States Energy-System, a Unified Planning Framework, PhD. Dissertation, Polytechnic Institute of Brooklyn, 1972.
8. Hoffmann, K. C., A Unified Framework for Energy System Planning in *Energy Modeling, Resources for the Future*. Washington, D. C. 1973.
9. FEA, Project Independence Report, U. S. Government Printing Office, 4118-00029, 1975.
10. Nordhouse, W. D., The Allocation of Energy Resources *Brookings Paper on Economic Activity*, No. 3, 1973.
11. Baughman, M.L. Dynamics Energy System Modelling, Report 72-I, Energy Analysis and Planning Group, MIT, Cambridge, 1972.
12. Deonigi, D. E., A Simulation of the United States Power Economy. *Proceedings of the American Power Conference*, Vol. 32, 1970.

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EXECUTIVE READINGS

Materials Management

By M. M. Varma
New Delhi : Sultan Chand & Sons, 1981.

Reviewed by S. C. Vohra
New Delhi

Although materials constitute the single largest cost factor in any enterprise, surprisingly not many books have been written on this aspect of business administration and out of the books that are available, not many have been written in the Indian setting. To that extent the present book is a welcome addition to the scant literature available on the subject. A truely comprehensive treatment of the subject has been attempted by the author who has amply succeeded in bringing out essential features of materials management in one single volume.

The book is divided into four sections. First section deals with introductory and general aspects of materials management. Second section discusses the managerial aspects including inventory control, codification, budgetting etc. Third section discusses the hardware aspects of storekeeping and the last section is devoted exclusively to purchases and procurements.

While the treatment of the subject is fairly exhaustive to the extent that almost all aspects of materials management have been touched upon, the book could be given a more practical orientation by inclusion of some case studies. While discussing organisation for materials management, actual structure prevailing in some public or private enterprises could be given so that the reader can match theory with actual prevailing practices. Similarly, illustrations of a few actual applications of A-B-C analysis could make the reader appreciate the flexibility that is permissible or the variations that one could come across while actually using the technique. Incidentally while discussing this most popular technique of selective Inventory Control, the author has not described the detailed procedure for identifying items of each class. Similarly applications and limitations of V-E-D analysis could have been described in a little more detail (The technique is inapplicable in manufacturing units where all the parts of a finished product are equally vital).

Another chapter which required a more detailed discussion of practical application is the one on computerisation. In addition to the general discussion on the subject, specific applications in the field could have been discussed in the style of P. Gopalakrishnan and M. Sundaresan's 'Material Management — an Integrated Approach' from which the author has liberally quoted.

A notable omission in the book is a chapter on Vender rating. Since one complete section has been devoted to the subject of procurement, the methodology and application of vender rating including the guidelines issued on the subject by the Bureau of Public Enterprises would have been a useful addition.

Notwithstanding the foregoing, it is an exhaustive treatise on the subject. A notable feature of the book is that the content has not been lost in the jungle of theory and semantics—a fault found commonly in most management books. Written in simple language and lucid style, it really helps the uninitiated in comprehending the subject. The book is aimed at meeting the requirements of those who have been recently inducted into the materials management departments of various industrial undertakings and students undergoing various management courses. This aim the book amply fulfills. However those who may be interested in the latest developments in the field are likely to be disappointed. Moderately priced at Rs. 20/- the book is free from printing errors and can be easily recommended as a text book for various management courses. □

Indian Feudalism

By R. S. Sharma
New Delhi : Macmillan Publishers, 1980.

Reviewed by V. S. Mahajan
Punjab University, Chandigarh

This is the second edition of the author's book which appeared first in 1965 as a consequence of six lectures that he had delivered in the Calcutta University in 1964. Here the author traces in historical perspective the development of land grant system which originated from the Gupta period and became more and more popular in the post-Gupta period and had ultimately given rise to the emergence of the landlord (or feudal) class controlling the village economy as well as wielding considerable power over the peasant and artisan classes.

Originally the lands were given to priests and temples who had the right not only to realise revenue but also to govern the inhabitants of the village, as well as punish thieves, offenders against families, properties, etc. In return for such land grants the priests were obliged to render religious services, which might secure spiritual welfare of donors and their ancestors. While in the Gupta period there is no direct evidence of land grants to military and administrative services, the author admits that such grants to these people cannot be entirely ruled out. However, in the post-Gupta period the system of land grants to government functionaries including army personnel is said to have gained importance.

It is interesting to note that these land grants played an important role in the colonisation of new areas=particularly virgin tracts and forests, and thus helped in the agrarian expansion over vast areas of the country. Further the priests or Brahamans played a significant role in encouraging new methods of cultivation in backward areas which brought prosperity into these areas. Also some of the beliefs and rituals sponsored by priests encouraged material progress among the tribals. Thus, dissemination of the idea that the killing of a cow was as bad as homicide was intrumental in the preservation of cattle wealth, so essential for agriculture. Such feudalism as existed in early India also encouraged integration of this vast country at a time when hardly any means of communication existed. This happened through providing the tribal people with scripts, calendar, art, literature and a new way of life.

On the negative side these land grants led to the eventual fragmentation of political authority as "the brahamans and their patrons came to identify themselves with their localities and helped foster local culture, thus laying the basis for the rise of regional nationalities in the country". Thus feudalism which had initially helped to bring about some sort of social, political and economic order in the country, in due course of time resulted in the weakening of power of the central authority.

The book is indeed a scholarly contribution in the field of ancient agrarian system in the country and the relationship that existed between different classes of the society. It is very well documented and written in an elegant style. □

Feasibility Study

By Dr. S. N. Bhattacharya
New Delhi : Metropolitan Book Co. (P) Ltd., 1981

Reviewed by Navin Chandra Joshi
Moti Lal Nehru College, New Delhi

The author makes a thorough investigation into the

several aspects that are necessarily involved in feasibility studies of projects in developing countries. He commends such studies for all levels of projects. For example, he demolishes the belief that investment in industries pertaining to infrastructure in backward areas does not give adequate return. But then, according to the author, this is a misplaced view for analytical investigations have proved that it is not so.

The introductory chapter of the book is quite long, running over to 73 pages. Subsequently, there are chapters on market, resource, technical and financial analyses, followed by a couple of appendices and a bibliography. The arrangement in the book is not approriate while its contextual presentation is rather tardy. All this goes to take away the sustained interest of a reader. The author tries to put in as much as possible, though very briefly, in each chapter and thereby reduces the utility of the content, restricted as it would be for the uninitiated and beginners. One wishes that some kind of research study had been undertaken by the author instead of treading the much-beaten track.

In market analysis, the author gives methodology for market survey, major steps for marketing feasibility and marketing policy. Likewise, he lays stress on resource analsis by suggesting that cost should be low and this would depend upon factors like availability and cost of raw material, skilled, semi-skilled personnel, power and water and other facilities in the area. After establishing that the resource is an important factor in deciding the location of the unit, one has to know the available raw-material surplus that can be utilised by the industry in that area.

The technical analysis in a feasibility study of a product involves proper location of the unit, proper size of the plant, suitable process of manufacture, factory layout, and organisational set-up. The author points out that technical analsis is an important part of the entire feasibility study and many things like cost of production, efficiency of labour, etc., depend upon technical viability of a project. Further, the financial analysis would help an entrepreneur underst and the investment aspects of a proposed industrial enterprise. This involves a study of break-even point, fixed and working capital, ratio analysis, etc. The chapter on financial analysis is a bit sketchy as important elements like cashflow have not been discussed.

Suggestions have been given in a separate chapter for future investigators of a feasibility team so that their study may become purposeful, as far as possible. The suggestions are sometimes very basic such as how the team should be composed, how the members should proceed with the work and so on. The author's useful suggestions pertain to coordinated development, developmental leverage, test of social disability and the test of balance of payments effects. These are well worth noting and may be considered by future investigators.

Interspersed in the chapters are some case studies discussed and explained by the author. Much could have been added and a lot deleted from the book. All in all, it is a good attempt at piecing together various elements, ideas, cases, concepts, suggestions in a book form which a member of a feasibility study team may like to glance through. □

Small Farmer's Development Programme

By S. M. Pandey and J. S. Sondhi
New Delhi : Shri Ram Centre for Industrial Relations and Human Resources, 1981.

Reviewed by J. K. Jain
National Productivity Council, New Delhi

The book under review is a study of Small Farmers Development Agencies in Budaun, Fatehpur, and Rae Bareli districts of Uttar Pradesh. The Study essentially evaluates and examines the Pattern of assistance utilisation by the participants of the programmes offered by S.F.D.A.

The report has been divided into five chapters. The initial two chapters deal with the programmes offered for the development of small and marginal farmers and with basic information relating to land-use pattern, cropping pattern, level of literacy etc. The third chapter is devoted to the data and information gathered for the study such as size of holdings, distribution of holdings, value of assets, occupational distribution, family

composition and literacy and age of both participating and non-participating house-holds in the programmes of SFDA in the selected districts. The last two chapters deal with the impact of SFDA assistance on the economic development of participating house-holds and general findings associated with the SFDA's programme.

The authors emphasise the fact that the programmes are financial target oriented rather than physical target oriented. The gap between target and achievements with respect to irrigation, dairying, poultry seems to be because of implementation problems rather than conceptual one The authors also highlight the problems associated with the programme. These include a lack of awareness of the programme among non-participants, the key role of village level workers as a source of information, the significant shift in occupational distribution of the participants, lack of control and monitoring system, lack of infrastructure, and human aspects associated with the project implementation.

Such micro level Studies are of relevance not only to the people associated with SFDA in the districts of Budaun, Fatehpur and Rae Bareli but also to Planners, Administrators & Researchers who are associated with the Rural Development programmes at State and National level. □

Project Planning and Appraisal in Planned Economy. The Indian Context

By D. K. Jain
New Delhi : Uppal Publishing House, 1981

Reviewed by R. M. Sahay
National Productivity Council, New Delhi

Scientific planning and appraisal of projects has gained considerable significance in recent years. Emphasis is placed on this aspect by national and state level planning bodies of the government and by the various project financing agencies, both national and international. A sequel to this has been a substantial flow of literature on this subject, especially in the late seventies. The book under review is an attempt to integrate the subject with national planning and make the book a handy reference for academicians and practitioners.

The author has given a check list of various aspects taken into consideration by project appraisers at the various stages of the pre-ante evaluation of the project, e.g. ch. 3, ch. 5 etc. He has also provided tables indicating the heads under which information is required by various agencies appraising a project. In this connection I must say the author has used his experience of PAD, planning commission effectively.

However, in the attempt for a concise and simple presentation, the author has not been able to do full justice to the methodology and techniques of project planning and appraisal. Even the first six case studies presented by the author are too elementary and do not enter into the detailed mechanics or exposition of the methodology. Only in the seventh case are some of the requirements of project planning and appraisal exposed, but here also, methodologies adopted are not clarified.

In the chapter dealing with 'Technical Appraisal and the selection of Technology and Know How', the various questions in the minds of the appraisers have been identified. The author has failed to bring out certain important linkages and implications of technology choice, which are very important from project planning and appraisal point of view in a planned economy. For example, the choice of technology has a direct bearing on questions of employment, quality of the product, long and short term demand for the product, scale of operation and operational efficiency, the availability of inputs, and markets etc., and their social bearings. Similarly, the question of location has been discussed only by raising questions without bringing out the specific socio-economic and regional development aspects of the location of projects and their policy implications or the locational logic of projects.

The estimation of financial capital and operational costs of the projects have been dealt with competently. The author has exhibited a fair degree of insight into problems of cost runs and has provided extensive listing of heads under which costs are

covered by various financing agencies. In the section on "Profitability and the Risk Analysis" various methods are used to assess profitability with the help of elementary examples. However, the discussion on investment criteria does not bring out the uncertainty that exists in any calculation of the future and the various ways to minimise the element of chance and increase the reliability of the results obtained, though the author has made an elementary tabular presentation of the sensitivity analysis. Similarly implementation and management technique have only been introduced rather than being explained and discussed.

Social cost-benefit analysis, a highly talked about technique of project appraisal, to determine the social worth of a project has been discussed with the help of the two most-commonly used methods, UNIDO (1972) and the O.E.C.D. (1968). Following the two systems, there has been a lot of debate on the subject especially with respect to the calculations of shadow price of both inputs and outputs, leading to suggestions for considerable modification of the two methods. The author has not brought out the various questions under debate or the modifications suggested. The details of the system adopted or the calculation of social cost benefit analysis vis-a-vis the financial calculations has not been exposed by the author.

It would have been much more useful to build the project planning and appraisal in planned economy with an in-depth case study, bringing out the various aspects and also the stages of project planning, appraisal and the techniques adopted showing the various constraints and the relationship with planning process. This would have helped the practising readers in easy understanding of the methods and systems of project planning vis-a-vis the seven short case studies, presented in the book. □

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Project Scheduling With Limited Resources—A Survey

P. K. BHAUMIK
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This survey paper defines the project scheduling problem and emphasizes the difficulties involved especially in multi-resource multi-shop and multi-project settings. It describes some of the heuristic methods available in published literature and summarises the findings of comparison of heuristic decision rules.

The classical CPM/PERT approach considers the various technological constraints inherent in the activities comprising a project and successfully identifies the critical path or the set of activities having a zero slack. During project monitoring and control, the project manager is expected to exercise a differential amount of supervision and control, the degree of control being inversely proportional to the amount of slack an activity has, subject to the condition that projects are continually updated and new values of activity slacks calculated at each updating.

Technological constraints alone have been considered in this analysis and it is assumed that all activities which satisfy the technological constraints can be performed, if necessary, simultaneously. However, real projects require resources, all of which may not be available in unlimited quantities and the finite amount of resource availability places additional constraints on the network. In this sense, the length of the critical path places a lower limit on the project duration which may not be achievable in view of the additional constraints.

Thus, we can define a plan as a "coordinated model of the order in which we must perform all the activities required to complete our project" (Moder, 1964). Scheduling can begin after plan is complete, since the plan provides the basic framework within which activities have to be scheduled. By scheduling we mean the determination of calendar dates of starting and completing each activity, and a feasible schedule is one which satisfies both the technological and the resource

availability constraints. This paper describes the project scheduling problem, analyses why optimal solutions are difficult to find, summarises most of the commonly used heuristics and discusses the comparisons of heuristics carried out.

Let us look at a somewhat realistic description of a project to understand the magnitude of the problem involved in determining an 'optimal' schedule. We assume that we know the list of activities their interdependencies as well as the duration of each activity (which may only be an estimate).

The first difficulty is in specifying the objective function : should one try to minimize the total duration of a project, or attempt to have a uniform level of manpower employed in the project or should one try to maximise the utilisation of some critical resources. These are questions which are not easy to answer and even if one is able to determine an 'optimal' schedule as defined by the objective function, it may not be the best from the cost-benefit considerations as viewed by the project planner.

Similarly, when it comes to specifying the resource availability, it can seldom be stated without qualification. For example, if the resource under consideration is manpower, it can usually be varied at a slow rate, provided sufficient notice is available. Even when the number of men is fixed, overtime working or week-end working are possibilities that can increase the resource availability, albeit at an increased cost.

Further difficulties are introduced by the existence of various alternatives associated with the project plan (Davis, 1966). Different methods are often possible to achieve the final project specification, different rates of work, with different costs associated with them, may be possible for any particular method and finally, the project may require a large number of resources, each of which is limited in amount and is to be shared by many activities.

Moreover, while preparing or revising a project schedule, one has also to consider factors such as the following :

(i) Activity resource requirements

Some resource requirements, e.g. manpower required are 'rate-constant' in the sense that if the activity duration increases or decreases, the resources required will also increase or decrease correspondingly since it is consumed at a uniform rate. On the other hand there are other resource requirements, e.g. materials required which are 'total constant' and are independent of the activity duration. One has to keep track of this while revising a project schedule.

(ii) Complex resource requirements

In many cases, what is designated as an activity is actually a set of activities and as such the resource requirements listed may not all be required for the complete duration of the activity. There are two approaches available to handle such situations—either the activity is broken down into smaller activities each having its own resource requirement, or else the activity is scheduled only when all the resources are available for the complete duration of the activity, with resulting under-utilisation of resources.

(iii) Uninterrupted consecutive activities

Just as the project scheduler needs to know whether a particular activity can be split or whether, once started, it has to be completed, similarly it is also important to know whether interruption of the work-flow between certain consecutive activities is undesirable.

(iv) Activities with force finish

The concept of activity splitting for scheduling purposes is further qualified by the point of time under consideration in the life of the activity. An activity which can be split in its initial stages may become unsplittable during its final stages (i.e., may require a force finish).

(v) Resource availabilities — normal and threshold levels

When specifying resource availabilities, especially manpower availabilities, it may be necessary to specify the two levels – the normal level and the threshold level indicating the maximum possible availability including overtime, weekend working etc.

(vi) Project duration threshold

Since a project schedule finally selected is expected to be a compromise between earliest

completion date, efficient resource utilization and economic costs, it becomes apparent that there should be some amount of flexibility in specifying the completion date of the project—this can be done for example, by specifying the preferred completion date and the maximum permissible completion date.

AN ILP FORMULATION OF THE PROJECT SCHEDULING PROBLEM

To further bring home the computational intractability of the optimum schedule problem, we present here a highly simplified verison of a project scheduling problem having the following characteristic (Gonguet, 1969) :

(i) We wish to minimize the project duration

(ii) Split jobs are not allowed

(jii) There is only one level of resource availability—no threshold level.

Variables :

$$\text{Let } x_{j,\tau} = \begin{cases} 1 \text{ if job j is scheduled at time t;} \\ 0 \text{ otherwise} \end{cases}$$

$$\Sigma x_{j,t} = 1, \ (j = 1, 2, \ldots\ldots\ldots, N)$$
$$t \varepsilon D_j$$

Where D_j is the set of starting dates for job j and may be found using a PERT program. The number of elements in D_j is equal to the total float of job j (TF_j) plus one. Therefore, there are $\Sigma_j (TF_j + 1)$ variables.

Technological Constraints :

If S_j is the set of jobs which are immediate successors of j having s_j elements in it,

$j_i \varepsilon S_j$, scheduled finishing time of $j \leqslant$ scheduled starting time of j_i

$$\text{or } \Sigma_{t \varepsilon D_j} t\, x_{j,t} + d_j \leqslant \Sigma_{t \varepsilon D_{j1}} t\, x_{ii,t}$$

There are Σs_j constraints of this kind.

Resource Constraints :

Let $1_{r,j}$ be the level of resource r required by j.

$$\text{If we define } I_{r,i,d} = \begin{cases} I_{r,j} \text{ if } I \leqslant d \leqslant d_j \\ O \text{ otherwise} \end{cases}$$

where d_j is the duration of job j and $A\gamma,t$ is the availability of resource r at time t and P is the set of all jobs, then at time t,

$$\Sigma_{j \varepsilon P} \ \Sigma_{t \varepsilon D_j} I_{r,j,t_l} - t + 1.\ X_{j,t} \leqslant A\gamma,t_l \ (t_l = 1, 2, \ldots\ldots\ldots, W)$$

Where W is the total number of time units in the scheduling period. There are, therefore, $W \times R$ constraints of this kind, where R is the number of different resources with limited availability.

Objective function :

If it is assumed that in the project, P, there is a single job je with $S_{je} = O$, then the objective function becomes

$$\text{Min } Z = \Sigma_{t \varepsilon D_{ie}} t\, X_{je,t}$$

It should be noted that the above formulation requires specification of W—the total number of time units in the scheduling period, i. e., one is reasonably certain the project can be completed before W time periods with the given resource constraints. In an example cited by Gonguet (1969), formulation of a project having 16 activities and 13 events requires 239 variables and 63 constraints with a scheduling period of 32 time units (the critical path length is only 22 time units) and requiring a single resource. One can well understand that the time required to reach optimum solutions will be prohibitive for practical sized projects.

MULTI-RESOURCE, MULTI-SHOP AND MULTI-PROJECT SCHEDULING

Even if there is one resource which is not unlimited in availability an optimum schedule is quite difficult to find. However, real projects are constrained by limited availability of many resources. Patterson (1973) mentions that "researchers characteristically assume that three different resource types or groups are the maximum that can be required to complete any one activity" However, in a study of 34 projects of the Research and Development Department of the U. S. Naval Ammunition Depot, he found that as many as 7 of the 13 possible resource groups

can be required to accomplish an activity. In many cases different skill categories or crafts of workers constitute different resource groups.

Moreover, the same skill category may be organised into different shops and when an activity is performed in a particular shop, it is expected to use the personnel from that shop alone. Thus, in a multi-shop situation, the same resource group is further subdivided into sub-groups and each subgroup creates a constraint which has to be satisfied by any feasible schedule.

When more than one project has to be scheduled, each one sharing resources from a common pool, it is a case of multi-project scheduling. It is apparent that all the difficulties we have discussed above in case of project scheduling become much more acute and relevant in this case e. g., what should be the objective function to be optimised by a large construction company executing many projects at any point of time? Should it be the minimization of the total duration of all projects or a uniformly high level of resource utilization?

Multi-project scheduling is generally handled in one of two ways. Woodgate (1964) suggests that one can fix relative project priorities in addition to the normal network constraints and then use the relative project priorities in conjunction with other criteria while allocating resources. The priorities may be decided based on the relative size of the project, penalty per unit delay, importance of the project to the user and any such external consideration. In the other approach suggested by Martino (1968), unrelated projects are linked by adding some leading activity from a common 'start' event to the start of each project. This leading activity is also assigned a duration depending on the minimum gap desired between the start of any two projects. Similarly, ending activities are also added from the ending even of each project to a common 'and' event and the duration assigned to the ending activities are such that there is at least one critical path in each project. Thus, if the duration of the jth project is d_j and the leading activity duration of the jth project is l_j, and if e_j is the duration of the ending activity of jth project, then

$$e_j = \max_j(d_j + l_j) - (d_j + l_j)$$

This linked project can be taken as a single project and scheduled.

HEURISTICS IN PROJECT SCHEDULING

In most real projects many activity time durations are only estimates and as such the optimal schedule may not be superior to a near optimal solution due to the inherent inaccuracies in estimation.

It is not at all surprising therefore, that most of the development in project scheduling has been in developing different heuristics. In what is perhaps the first paper in project scheduling, Kelley (1963) classifies heuristics in project scheduling into two classes :

(i) Serial Method : In this method of project scheduling, the heuristic scans the list of activities that can be scheduled at any point of time and decides which activity should be scheduled. Once the decision is made, the complete activity is scheduled and the process is continued to find the next activity which can be scheduled.

(ii) Parallel Method : In this method the heuristic proceeds one time unit at a time and if all constraints are satisfied an activity is scheduled during that time period. An activity which is scheduled in one time period may not be scheduled in the time periods immediately following this because of resource non-availability and thus there may be gaps between the time periods when resources are allocated to a particular activity.

These two methods are analogous to the event-oriented approach and the activity-oriented approach usually followed in system simulation and one can say that the parallel method is more flexible since it can handle activity splitting which is not possible if one is using the serial method of project scheduling.

CHARACTERISTICS OF SOME HEURISTICS

Because of the potential pay-offs, many of the heuristics in the area of project scheduling

are offered only as commercial packages and the details of the algorithm are not disclosed. It appears that most of these follow the parallel method since they offer possibilities of activity splitting, using resource availabilities at normal and threshold levels, consecutive activities and other such practical constraints.

We will now describe some of the heuristics available in the published literature emphasing the criteria used for resource allocation in each.

(i) *Multiple-resource Allocation Procedure (MAP)*

In this serial heuristic, among the activities that satisfy the technological constraints, precedence is assigned according to the following tests and in the order indicated :

* least total float
* larger need for overall resource
* larger crew size
* sequence code

(ii) *Resource Scheduling Method (RSM)*

This is also a serial heuristic and any existing resource conflicts in a time period are resolved by forcing one of the activities involved to follow another activity which requires the resource causing the conflict. The two activities involved in this manipulation are chosen so as to minimise the increase in project duration that results from this sequencing. The increase in project duration resulting from forcing activity j to follow activity i is :

$$IPD_{ij} = \text{Max. } (O,\ EFT_i + DUR_i - LFT_j)$$

$$= \text{Max. } (O,\ EFT_i - LST_j)$$

(iii) *Brooks' Heuristic*

Again a single pass heuristic in which the resources are allocated in the decreasing order of Maximum Remaining Path Length(MRPL) where

$$MRPL_{ij} = T_E \text{ (terminal event)} - T_E(i) - Slack_{ij}$$

Since $T_E(i) = EST_{ij}$ and $Slack_{ij} = LST_{ij} - EST_{ij}$

$$MRPL_{ij} = T_E \text{ (terminal event)} - LST_{ij}$$

and so a decreasing order of MRPL is equivalent to an increasing order of LST.

(iv) *Kelley's Heuristic*

The activities are listed in the order of precedence, i. e. with the activity arrow head numbers increasing and in case of a tie in order of increasing total slack. Working down the list, each activity is scheduled as early as possible. If resources are not available try the following in the order listed :

(a) reschedule one or more of the competing activities within the limits of their total slack.

(b) increase or decrease the duration of the activity in question or split it if it can be split.

(c) increase or decrease the duration or split, if possible, any of the competing activities.

(v) *Scheduling Program for Allocation of Resources (SPAR-1)*

In this heuristic, activities are scheduled, starting with the first period, by selecting from the list of those currently available and ordered according to their total slack. Activities in the list are scanned sequentially. Each activity has a probability r (which is an input parameter) of being considered for scheduling. If an activity is not scheduled, the next on the list is considered with probability r, and so on. Activities left out in first pass are re-considered during second pass and so on.

(vi) *Woodgate's Heuristic*

This follows the parallel method and if an activity is available for scheduling it is put in a scheduling queue. Within the queue, a typical priority sequence is as follows :

1. Activities having special restrictions such as non-splittable, force finish or consecutive conditions.

2. Activities with the least amount of work required for completion.

3. Activities with the smallest amount of early free float, where (Early Free Float)$_{ij}$ = T_E (j) — T_E (i) — Duration$_{ij}$

4. Activities with the smallest amount of total float.

5. Activities with superimposed priorities, such as project priorities(multiprojects), and priorities given to activity projects.

The sheduling method is to take the first part of the first activity in the queue and decide whether to schedule or delay it. The actual scheduling decision is made by calculating the following four factors and looking up a decision table which contains the appropriate decision for each combination of values of these factors.

1. Time situation with respect to project completion date
   a. Positive total float
   b. Positive total float using project threshold time
   c. Negative total float
2. Resource situation with respect to the activity requirement
   a. Enough with normal resources
   b. Enough with threshold resources
   c. Not enough
3. The amount by which an already partially scheduled activity will have to be unscheduled if not scheduled in this period. This will be zero for all activities which can be split.
4. Time situation with respect to project completion date if the portion of the activity already scheduled is to be cancelled and the activity rescheduled.
   a. Positive total float
   b. Positive total float using Project Threshold time
   c. Negative total float

If an activity cannot be scheduled in a particular period, it will be delayed. In this, context, delay might mean one of the following :

a. Delaying an activity not already partially scheduled.

b. Splitting the activity if it is not designated non-split.

c. Restarting the scheduling of the entire activity if it is already partially scheduled and designated non-split.

OPTIMUM SCHEDULE

A heuristic can be called good only if it can produce optimal or near optimal schedules. In the absence of an optimal schedule, one can only assess the relative performance of heuristics and although one is superior to another, it may still be far from optimal.

In a bounded enumeration procedure suggested by Davis and Heidorn (1971), each activity is broken down into a number of unit time tasks, the number being equal to the duration of the activity in time units. One can define a feasible subset of these tasks as a subset which can be taken up on a single time unit and represent such a subset as a node on a graph, the nodes being connected by arcs if one subset can succeed another on the following time period. The scheduling problem then converts to the problem of finding the path with the minimum number of arcs from the starting node to the ending node such that the feasible subsets are mutually exclusive and collectively exhaustive. Looked at this way, the problem is similar to an assembly line balancing problem where a cycle time is specified (similar to the resource availability being specified). In fact the procedure uses an algorithm to generate all feasible subsets which was originally proposed for the line balancing problem. However, certain modifications have been suggested to use stronger bounds and cut off many feasible subsets which are unlikely to be on an optimal path. This requires the use of another heuristic to provide a feasible schedule which is used to find the stonger bounds. Davis (1969) used RSM rule for this purpose and reports that in all cases tested, the optimal schedule was better than the one given by the RSM heuristic.

Comparison of heuristics is made further

difficult because of differences in the objective functions and the performance measures on which these can be evaluated. A heuristic which is the best in minimising the makespan may not be as effective in minimising the total throughput time for all projects and so on. Some of the comparisons presented here are based on single performance measures whereas some others use more than one measure of performance.

Similarly, many heuristics are different in the degree of alternatives that they can accommodate e.g. some permit activity splitting whereas some others do not. These again make comparisons difficult.

In view of this, many of the comparative studies evaluate only the decision rules rather than the total heuristic. For example, the studies by Fendley, Knight, Pascoe, Patterson, Davis and Patterson evaluate some 'common' heuristic decision rules, a few of which are mentioned below :

1. *Least Total Float (LTF)*

The total float available in an activity is utilised to see if it can be delayed. The slack is continuously updated and any delayed activity has its float reduced by the amount of delay. As pointed out by Davis and Patterson (1975), under the parallel method of scheduling, this rule is equivalent to a Minimum-LST-first rule.

2. *Minimum Late Finish Time (LFT)*

Activity LFT, as found by usual critical path methods is used to assign priorities in scheduling; the logic here being that LFT considers the effect of both LST and the duration of the activity. Thus, if two activities have the same LST, the one having a shorter duration will be scheduled first so that resources are released earlier.

3. *Resource Scheduling Method (RSM)*

This has been described earlier. In a study of three heuristics reported by Shaffer (1975), this rule was found to be the best.

4. *Shortest Imminent Operation (SIO)*

This is the project counterpart of the SPT (Shortest Processing Time) rule extensively used in job shop scheduling where it has been shown effective in reducing the average total processing time for a group of jobs.

5. *Greatest Total Resource Demand (GTRD)*

This rule assigns priorities to activities based on the total resource unit requirements of all types, with higher priorities given for greater resource demands. The rationale seems to be to give priority to potential bottleneck activities.

6. *Greatest Remaining Resource Demand (GRRD)*

It is the dynamic version of the GTRD rule and assigns priorities based on the total remaining resource demand.

7. *Greatest Resource Utilisation (GRU)*

This rule gives priority to that combination of activities which result in the highest resource utilisation in each scheduling interval. A zero-one integer programming problem is solved in each period to find such a combination.

8. *Most Jobs Possible (MJP)*

This rule also solves a zero-one integer programming problem in each scheduling period to find that combination of activities which result in the maximum number of activities scheduled in that period.

9. *Randomness (RAN)*

If a set of activities tie on any given priority (e.g. total float), the tie is broken using these at random. This, rule, therefore goes along with some other scheduling rule described earlier.

10. *Reschedule (RES)*

This rule is also an associated one and is used along with some other rule which first prepares a schedule. A new schedule is then developed using as activity priority the quantity of resource-units (i.e, resource level $\times$ duration) required by the activity. The resource used for this purpose is the one which had the least amount of idle time in the old schedule.

COMPARATIVE STUDIES ON HEURISTICS

Quite a few comparative studies on different heuristic decision rules have been made in the recent past but many of these are reported in unpublished theses and as such not readily available. However, findings of most are reported by Shaffer (1975) and Patterson (1973).

Most of the comparative studies have been conducted on projects of sizes much smaller than real projects and it may be argued that these results may not be applicable to large projects. This question has not been studied in depth in the researchs reported. In one of the studies, however, Pascoe (1975) checked his major findings on projects having twenty activities with a network of 100 activities as well as a large building construction network taken from practice and he found that his findings are invariant with the size of the project.

However, different researchers have found different heuristics superior and if size is not the contributing factor then there are other factors which affect the performance of heuristics. Gonguet (1969) talks about classifying projects based on certain factors and Pascoe (1973) suggests a classification scheme for project network parameters (e.g. complexity, density, resource obstruction etc.). This is one area where more research need be done so that one can recommend a heuristic once the parameters of the project to be scheduled is known.

REFERENCES

1. Davis E. W., Resource Allocation in Project Network Models—A Survey. *Journal of Industrial Engineering*, Vol. 17, No. 4, April 1966. pp. 177-188.

2. ————————, Computational Experience with a new Multi-resource Algorithm in Lombaers H. J. M. (ed.), *Project Planning by Network Analysis*, North-Holland, 1969, pp. 256-260.

3. ————————, and Heidorn, G. E., Optimal Scheduling under Multiple Resource Constraints, *Management Science*, Vol. 17, No. 12, August 1971, pp. B-803-816.

4. ————————, and Patterson J. H., A Comparison of Heuristic and Optimum Solutions in Resource-Constrained Project Scheduling. *Management Science*, Vol 21, No. 8 April 1975, pp. 944-955.

5. Gonguet L., Comparison of Three Heuristic Procedures for Allocating Resources and Producing Schedule in Lombaers H. J. M. (ed.), *Project Planning by Network Analysis*, North-Holland, 1969, pp. 249-255.

6. Kelley J. E , : The Critical Path Method : Resources Planning and Scheduling, in J. F. Muth and G. L. Thompson, (eds.,) *Industrial Scheduling*, Prentice Hall, 1963.

7. Martino R. L., *Resources Management*, Waynes Pa., Management Development Institute, 1968, p. 147.

8. Moder J. J., and Phillips C. R. *Project Management with CPM and* PERT, New York : Reinehold Pub. Corporation, 1964, p. 283.

9. Patterson J. H. Alternative Methods of Project Scheduling with Limited Resources. *Naval Research Logistics Quarterly*, Vol 20, No. 4 December 1973, pp. 767-784.

   Pritsker A. A. B., and Watters L. J., and Wolfe, P. M. Multiproject Scheduling with Limited Resources : A Zero-one Programming approach, *Management Sciences*, Vol. 16, No. 1 September 1969 pp. 93-108.

10. Shaffer L. R., Ritter J. B., and Meyer W. L., *The Critical path Method*, New York; McGraw Hill, 1965, 216p.

11. Wiest J. D., A Heuristic Model for Scheduling Large Projects with Limited Resources, *Management Science*, Vol. 13 No. 6, Feb. 1967. pp. B-359-377.

12. Woodgate H. S. *Planning by Network: Project Planning and Control using Network Techniques*, London : Business Pub., 1964, 33 p.

Productivity
1981, XXII, 3, 63-70

Government Policies and Growth of Sugar Industry Since 1900

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This paper evaluates the impact of government policies on the growth of sugar industry in the country in the 20th century and particularly in relation with the government controls since 1951. This has been attempted in the context of typical short-term and long-term problems of the industry and with a view to evolve an integrated approach towards sugar policy in the country.

Sugar industry which in India ranks second among the major agro-based industries, has a chequered history of development. The course of the industry's growth which has exhibited cyclical as well as seasonal patterns over a fairly long period of time, has been the resultant of a complex set of determinants including entrepreneurial dynamism and skills, technology demand pattern, population trends, monetary, fiscal and tariff policies and direct controls by the Government.

In the complete set of growth determinants, Government policies towards the industry have gradually emerged as a strong factor over time. Such policies have shifted the industry from a regime of the 'invisible hand' of the market forces to an area where its operations take place within a prescribed policy framework in respect of production, pricing, distribution and consumption. The need for such movement in the direction of greater controls has emanated largely from the crucial importance of the commodity as an item of mass consumption, consideration of the protection of the interests of cane growers and consumers through fair price fixations and from a need to lay down an infrastructure in which the industry could attain the warranted rate of growth.

The purpose of this paper is to highlight and evaluate the impact of Government policies on the growth of sugar industry in the country from the beginning of the 20th century to the present and in particular to demonstrate that with increasing degree of Government control since 1951, the industry has shown greater stability and

higher output performance. This has been attempted in the context of typical short-term and long-term problems relating to productivity and efficiency in the industry and with a view to evolve an integrated approach towards sugar policy in the country.

The Paper has been divided into three sections. Section I reviews Government policy towards the industry in the pre-Independence era and evaluates its impact upon performance during the period. Section II analyses changes in the State control policies and the industry's response to such policy variations since the inception of planning in India. Section III attempts to establish association between the degree of state control and the level of industry's performance within the broader policy framework and to point out some more prospective areas in which the Government may take active measures for the future growth of the industry.

I

In the period immediately preceding the middle of the 19th century, India was a net exporter of sugar which was largely of unrefined variety. Later, the British Government adopted a policy of free trade in sugar which brought Indian producers into straight competition with foreign countries and ultimately led to a gradual decline of the Indian enterprise. Around the turn of the 20th century, imports of sugar into India started rising significantly. The uptrend in imports was accounted for by the fact that the domestic demand-supply imbalance attracted the attention of foreign countries who, at that time, were making rapid technological progress related to superior cultivation techniques in respect of cane growing as well as extracting sucrose from beet and sugarcane. Such producers, moreover, were amply assisted by their respective governments by way of bounties and export subsidies.

Inspite of foreign competition, domestic industries continued to be inefficient and backward (Mac Kenna, 1926). The domestic pattern of consumption which favoured gur to sugar, acted as a strong demand constraint on the growth of good quality sugar manufacturing. Attempts to modernise the manufacturing process were only sporadic. The pace of development was sluggish, largely due to retarded growth of cane output, shyness of new capital and inadequate tariff protection by way of import restrictions. At the same time, sophisticated capital equipment was not allowed to be imported.

In 1919, the Government of India instituted a Sugar Committee to study the problems of the industry and to advise the Government for its expansion. One of the recommendations of the Committee was that the Government should fix a scale of prices for cane producers so that the latter were protected against exploitation by sugar factories. The recommendations were, however, largely ignored. The industry hovered around stagnation level till the onset of the Great Depression in early 1930's. A multiplicity of factors militated against its expansion. Some of the important ones were the excessively high revenue duties, downturn in sugar prices in leading international markets, little research sponsorship or financial support by the Government growing internal competition and outmoded techniques of cane cultivation resulting in poor supplies.

In view of the dismal state of affairs, the Government, on the recommendation of the Imperial Council of Agricultural Research, instituted Indian Tariff Board in 1930 to go into various aspects relating to grant of protection to the industry. The Board felt that, "it is essential in the national interest that the area under sugarcane should not diminish and that a fresh outlet should be provided for cane by encouraging the expansion of the white sugar industry. Unless steps are taken to develop the white sugar industry, a disastrous slump in the gur market is probable which will seriously affect agricultural classes, disorganise the agricultural system and involve the abandonment of better cane cultivation in large areas." (Gadgil 1972). The Board made a strong recommendation for granting tariff protection to the industry for a period of 15 years.

The grant of protection produced far-reaching salutory effects on the industry. Sugar imports fell drastically and sugar machinery imports registered an impressive rise. The petering out of imported white sugar gradually strengthened the demand for cane leading to considerable extension of area under the crop in various provinces. Between 1930—36, acreage under cane rose sharply. Sugar output in the country which was 350,000 tons in 1930-31 rose to 1,250,000 tons in 1936-37. The number of modern sugar mills rose from 29 in 1930-31 to 140 in 1936-37 raising

their share in total sugar output from 45% to 86%. During the period, sugar prices exhibited a constant downtrend due to raising of per capita sugar consumption. However, in the absence of a suitable price policy, cane growers were subject to monopolistic exploitation by millowners. They, being unorganised and their produce being perishable, had weak bargaining power on account of which they got unremunerative prices which, in many cases, were insufficient to meet even the costs.

Perhaps for the first time in 1934, the Govt. adopted a clear price policy by fixing minimum prices for cane and made them operative by passing the Sugarcane Act. The object was to stabilise cane prices at a reasonable level which was important on two counts : If prices tended to be unremuneratively low, cultivators switched over to other crops; had they been rewardingly high, they made manufacturing operations uneconomical. The beneficial effects of these measures were, however, in part, offset by a step-up in the rate of excise duty by Rs. 2-2-0 per cwt. in 1937. The hike was intended to make up for, as far as possible, the tariff revenue loss due to consistently declining sugar imports during 1930—39. Moreover, the Government was prompted to take this step to slow down the rate of expansion of the industry which it considered 'too rapid'.

Another significant development in the history of Government policy towards the industry was made when it controlled the release of sugar stocks and determination of sugar prices —a policy which still exists today. The measure was a sequel to arbitrary price hikes by the Indian Sugar Syndicate which was set up in June 1937 with membership of over 90 sugar mills. (Hirsch, 1961).

In the pre-Independence period, the pace of growth of the industry showed definitive response to Government policies that were followed from time to time. The response was more marked in respect of policies relating to import and export, excise duties, tariff rates and minimum price fixations. However, infrastructural facilities were conspicuously lacking and the size, pattern and distribution of the facilities were fundamentally intended to encourage the growth of capital in extractive industries and to drain off resources from the country. The structure of excise and tariff duties imposed on the industry were meant basically for raising revenue and bore little relation to the actual cost, conditions and growth requirements of the industry. The political and financial arrangements were designed to systematically discourage the growth of dynamic entrepreneurship.

The overall impact of protection on the growth of the industry was, however, beneficial. Adarkar, in 1941, observed an impressive growth of the industry during the last decade of protection despite problems relating to cane price, managerial efficiency, production techniques and optimum factory size. Protective wall was considered an absolute necessity to enable the industry to stand up firmly against the strong competition from foreign countries particularly Java. The industry enjoyed tariff protection for nearly 18 years till 1950 when it was withdrawn. As a result of the Government measure, the industry on the whole made spectacular progress.

II

Since the inception of planning in India in 1951, there has been a gradual extension in the area of intervention in the industry coupled with kaleidoscopic changes in Government policies towards the industry. The Government has been prompted to bring the industry under effective control on account of the fact that its product is an essential item of mass consumption. In addition, the price of the item is highly sensitive to the conditions of demand and supply which themselves are subject to seasonal fluctuations.

During the era of planned development of the economy, the industry made substantial progress. Total sugar production which stood at 11.18 lakh tonnes in 1950-51 rose to 64.16 tonnes in 1977-78—a record production in the current decade. The total number of factories in operation rose from 138 to 287 during the same period. The growth trend has been concommitant with some interesting structural changes. In the recent past there has been a marked trend in the locational pattern of the industry in favour of the southern regions, particularly Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh and Kerala. Production efficiency in the southern sugar mills is higher than those in the North. This is largely due to better organisational efficiency, economic use of by-products and mill-owned sugar farms. In 1978-79, the share in total sugar output was

highest in Maharashtra (36.04%) followed by U.P. (25.03%), Tamil Nadu (8.41%), Karnataka (8.34%) and Andhra Pradesh (5.32%).

A multiplicity of factors have contributed to the changing profile of the industry. Among these factors, particularly significant are the Government policies in respect of production pricing and distribution. Production controls are essential to bring the industry to warranted performance standards and price controls are needed to ensure reasonable price to the cultivator, producer as well as to the consumer. Inability to maintain parity in interests of the grower and the manufacturer may produce undesirable effects. *In a regime of 'invisible hand' of market mechanism, relatively higher cane price may be rewarding to the grower but is uneconomical to the millowner endangering a fall in sugar production : an abysmally low price on the other hand may be profitable for the industry but may lead to shrinkage of area under the crop in the next season.* Similarly, distribution controls have been justified on the ground that they are essential to ensure regular supplies and stabilise retail prices in the market to protect consumers' interests.

The growth of sugar industry in the planned era has taken place under changing shapes and shades of state controls and policies. Nevertheless, the degree of effective control has strengthened overtime. During 1952—63, the industry remained largely free from controls. The period was characterised by sharp fluctuations in production, consumption as well as prices. For example, in 1953-54, area under cane crop was just 14.1 lakh hectare and sugar output 10.17 lakh tonnes. The corresponding figures in 1960-61 were as high as 24.13 hectares and 30.26 lakh tonnes respectively. In order to reduce the amplitude and frequency in the production and price movements of cane and sugar, the Government adopted some control measures in 1963-64. A system for achieving equitable distribution of cane supplies between sugar factories and khandsari and gur producers was evolved. To ensure reasonable return to the grower, a schedule of minimum cane price was worked out.

The response to the measure was quick and encouraging. Area under the cane rose from 22.49 lakh hectares in 1963-64 to 26.03 lakh hectares in 1963-64 and further to 28.36 in 1965-66. Sugar production in the corresponding years rose from 25.62 lakh tonnes to 32.32 lakh tonnes and further to 35.32 lakh tonnes. The situation, however, received a set-back from the severe drought of 1966-67 which sent the industry reeling for 2 years. Sugar production during 1966-67 was at the rock-bottom level of 21.59 lakh tonnes—the lowest figure since 1963-64.

In view of the dismal position, the Government resorted to the policy of partial decontrol. The following two years were marked by quick recovery. In 1969-70, sugar production scaled a new peak at 42.61 lakh tonnes. In view of comfortable supply position, controls on sugar were lifted in August, 1971. The consequences were again quick to follow. In 1971-72, production took a deep downturn. There was a substantial diversion of cane supplies from sugar factories to khandsari and gur purchasers because of more remunerative prices offered. The result was a sharp escalation in sugar prices which prompted the Government to introduce in June 1972 statutory partial control on the distribution and prices of sugar. Under the policy,

(i) The statutory minimum cane price was raised from Rs. 7.37 to Rs. 8.00 per quintal, linked to a base recovery of 8.5% with a premium of 9.4 paisa for every increase of 0.1% in recovery;

(ii) The proportion of levy sugar was increased from 63.5% to 70%;

(iii) Same issue price of levy sugar price was fixed throughout the country; and

(iv) Efforts were to be made to create sufficient buffer stocks of sugar.

To counter the diversion of cane supplies from sugar factories to its competitive users, the Government stressed the policy of granting some fiscal incentives in the form of excise rebates to the industry so that it could offer competitive prices to the growers. The policy was followed for three consecutive sugar seasons 1972-75.

The dual pricing policy was abandoned on August 16, 1978 in favour of complete decontrol. During 1977-78, total sugar availability stood at 80.32 lakh tonnes (including carryover stocks).

Table 1

Production, Consumption, Exports and Carryover Stocks of Sugar during 1960—81.

(In lakh tonnes)

Year	Opening stock as on Oct 1	Production during the season (Oct—Sep)	Total supply available	Off-take		Closing stock as on Sep 30
				For internal consumption	For exports	
(1)	(2) =(7)	(3)	(4)= ((2)+(3))	(5)	(6)	(7)= ((4)—(5)—(6))
1960—61	7.42	30.21	37.63	20.87	1.94	14.82
1961—62	14.82	27.29	42.11	26.01	3.54	12.56
1962—63	12.56	21.39	33 95	25.02	5.66	3.27
1963—64	3.27	25.73	29.00	23.26	2.43	3.31
1964—65	3.31	32.32	35.63	24.46	2.67	8.50
1965—66	8.50	35.41	43.91	27.7.	4.30	11.87
1966—67	11.87	21.54	33.41	26.17	2.00	5.24
1967—68	5.24	22.49	27.73	22.10	1.29	4.34
1968—69	4.34	35.54	39.88	26.09	0.75	13.04
1969—70	13.04	42.62	55.66	32.70	2.12	20.84
1970—71	20.84	37.37	58.21	40.24	3.90	14.07
1971—72	14.07	31.08	45.15	37.90	1.33	5.92
1972—73	5.92	38.73	44.65	35.14	1.10	8.41
1973—74	8.41	39.48	47.89	35.22	4.39	8.28
1974—75	8.28	47.92	56.20	34.72	9.41	12.07
1975—76	12.07	42.62	54.69	36.70	9.67	8.32
1976—77	8.32	48.40	56.72	37.56	3.41	15.75
1977—78	15.75	64.57	80.32	44.90	2.53	32.89
1978—79	32.89	58.87	91.76	62.22	8.62	20.92
1979—80	20.92	40.00	60.92	52.56	2.39	5.97@
1980—81	5.97@	54.00@	58.97@	N.A.	Banned	—

@ Estimates

Source — Data India : Nov. 26 — Dec. 2, 1979.

The Economic Times, Dec. 20, 1979.

Partial control and dual pricing mechanism were abolished on two considerations :

(i) Sugar was in surfeit and it must be, therefore, decontrolled to permit free market mechanism to determine economic price; and

(ii) It was economically unfair to the rural masses as under it the Government tended to subsidise sugar purchases of the urban dwellers.

The decontrol had marked repercussions on the industry and trade. Prices came crashing down and many factories had to dispose off stocks at very unreasonable prices, in some cases at below production costs. The impact finally fell on the cultivator. Cane prices dipped as low as Rs. 4-5 per quintal and the cane output fell from 1769.7 lakh tonnes in 1977-78 to 1564.5 lakh tonnes in 1978-79. Correspondingly, sugar production sharply came down from 64.57 lakh tonnes to 58.4 lakh tonnes.

In 1979, there were frequent changes in Government policies amply demonstrating Government's indecision, diffidence and lack of serious thought to the matter. *Within a short span of three months there were as many as three policy variations.* In the first policy revision announced on September 11, 1979 the ex-factory price was fixed with immediate effect and retail price in the range of Rs. 2.91 and Rs. 3.00 per kg was to come into force six days later. Following virtual collapse of the statutory price control, the Government on November 30, 1979 announced higher retail prices ranging between Rs. 3.10 and Rs. 3.55 per kg. for various regions. With sharp disappearance of stocks into black market, the Government was compelled to re-examine its policy. The ex-factory price of sugar was raised with effect from December 1, 1979 due to 25 per cent rise in the cane price (to Rs. 12.50 per qtl.).

On December 17, 1979, the Government resurrected the same old policy of partial control over sugar with dual price mechanics (which was discarded on April 10, 1978) with immediate effect. Under the scheme, the ratio of levy and free-sale suger was fixed as 65 and 35. The uniform issue price of levy sugar to consumer throughout the country distributed through fair price shops was fixed at Rs. 2.85 per kg. Simultaneously, restrictions were imposed on the movement of sugar from one State to the other on trade account. With effect from Dec. 17, 1979, the revised rates of duty for levy sugar have been 8.5 % basic and 4.25 % additional respectively, and the revised rates for non-levy sugar 15.5 % and 7.5 % additional respectively.

After the new policy announcement, trends in the industry have been particularly disturbing. During the first four months of the crushing season 1979-80, sugar production showed a marked fall of 25 % compared to that in the corresponding period last year. More than 30% of the sugar mills were closed down early this year, some of them for want of cane supplies and others paradoxically despite cane availability. This was attributed largely to low cane availability, inability of the mills to pay competitive prices to growers and the consequential diversion of cane supplies to khandsari and gur producers who are able to pay better prices.

Government policies since 1951 have been aimed mainly at motivating the grower and the manufacturer to higher performance standards through suitable incentives, ensuring reasonable prices to the cultivators, producers and consumers, streamlining distribution systems to regulate supplies and artificial scarcities due to transport bottlenecks, disciplining trade to discourage hoarding and black-marketing and controlling consumption in accordance with existing supplies from time to time. The role of such policies has been intended to be promotional as well as functional. There is little doubt that the direct control measures, which have been tantamount to increasing Government intervention in the field of private enterprise, have adequate justification in view of the 'sensitive' nature of the commodity and the weight commanded by it in the computation of the cost-of-living index.

Ardent spokesmen of the freedom of enterprise have incessantly denounced extraneous controls over the production, pricing and distribution policies on the premise that they interfere with the free interplay of market forces and as such the industry is denied 'natural incentives' leading to sub-optimal performance. *The experience has, however, something different to suggest. Data pertaining to production performance of the organised mill sector in the country reveals that the growth trend on the average has been relatively*

more consistent with less fluctuations in periods of effective Government controls than during periods of relatively less control. Based on the effectiveness and coverage of Government controls, the plan period can be devided into three sub-periods: 1951-52 to 1962-63 when the industry has remained virtually without controls; 1963-64 to 1971-72 during which the control measures have been partial and relatively mild and 1972-73 to 1977-78 when the Government controls have been more comprehensive and effective. *Data reveals that with increase in the degree of control, the annual average production has risen and fluctuations in performance have been reduced. The variability (based on the co-efficient of variation) is maximumduring 1951—63, less during 1963—72 and least during 1972—78.*

Table 2

Variability In Sugar Production during 1951-63, 1963-72 and 1972-78

Period	Degree of government control	Co-efficient of variation in output
1951—63	Low	27.51
1963—72	Moderate	21.22
1972—78	High	18.56

Similarly, a remarkable stability has been seen in the area under cane cultivation since the Government took steps to determine minimum statutory cane prices.

The fixation of the levy sugar price from time to time along with a wider network of distribution system caused the weighted average price of the commodity to be much more stable than what would have resulted had such control measures been absent. When controls on sugar were lifted in August 1971 in view of the comfortable supply position, prices came crumbling down soon after, so that there was a steep decline in sugar production as well as area under cultivation in the next year. Similarly, when the dual price policy was abandoned in August 1978, sugar as well as cane prices took a deep downturn creating adverse effects on output in the next year. There have been many such other instances to show that relaxation of Government controls has harmed the interests of various groups, particularly cultivators and consumers.

The analysis of data pertaining to the impact of the Government policies on the industry reveals that the policy variables determine as well as have been determined by the actual position in the spheres of production, prices, distribution and consumption of the commodity. The policy adjustments have been found necessary in view of changing magnitude of gaps between actual and targeted performance. Unfortunately, the policy variations that have been seen in the recent past appear to contain elements of adhocism and political motivation rather than being the logical reaction to circumstances. The policies have been the target of severe criticism particularly among industrial circles on the ground that they lack imagination and a clear grasp of the gravity of the prevailing conditions.

The discriminatory practice of levying heavy excise duty on the organised mill sector incapcitating its ability to pay a competitive price to cane grower, substantial diversion of cane supplies to khandsari and gur producers and determination of the price of uncontrolled sugar at uneconomical levels are among the major short-run problems of the industry. Pricing policy in respect of levy sugar has been an aggravating factor. "An unrealistic cost schedule based on artificial averages has played havoc with the economics of sugar production.

While it may be difficult to defend the Government's present technique of price determination, at the same time it is hard to ignore the fact that the industry is running at low managerial and productive efficiency levels. The fundamental problem of the industry is essentially that of modernisation, renovation and replacement of obsolete capital equipment in order to raise technical efficiency standards and to bring down per unit costs—a task which appears fairly difficult in view of the present inadequate reserve funds with the industry. The aggregate cost of modernisation is estimated around Rs. 320 crores. *This is precisely one of the areas in which the Government needs to take up assistance measures as part of its long range development policy. Simultaneously, there is a strong need for evolving a suitable flexible cost based pricing formula designed to ensure normal profits to the producer and a reasonable price to the customer.* A recent decision by the Government to set up a Committee to study the cost structure of the industry with a view to enable the Government to evolve a suitable pricing formula and to help it monitor

the price situation is a timely and appropriate step in this direction.

With the assurance of reasonable return to the producer through such a price policy, a base would then be prepared for raising the proportion of levy sugar in the total distribution. This step is desirable on two counts : First, the present per head quota is inadequate and secondly, price of the uncontrolled sugar depends, among other things, on the difference between the actual requirement and the quota as well as on the regularity of quota supplies. With increase in the proportion, we can expect the price of free sugar (free-sale sugar) to show greater stability.

There is a strong need for buffer stock operations in respect of sugar. The measure was first suggested by the Sen Commission as far back as fifteen years ago. The theoretical justification for the step is two-fold. It would provide a cushion against fluctuations in cane supplies and sugar production; and, it would give the much-needed price-support to cane and sugar and protect the interests of growers, manufacturers and consumers from the periodic cycles of shortages and surpluses. Simultaneously, our present distribution system has to be overhauled to make its organisation more efficient and expeditious. It has been estimated that more than 25 per cent of family requirements on the average are catered to by free-sale sugar. *Disruptions in the levy sugar supplies have a fairly quick impact on the open market prices.*

The study leads to a conclusive evidence that Government policies have been an important factor in the growth of sugar industry in India since the beginning of the 20th century. The industry has shown marked responses to the policy variations that have been made from time to time. It is, however, *unfortunate to note that such policies have followed rather than preceded developments in the industry. The gradual extension of the area of hold on the industry is certainly welcome; but, what is needed is to give them an active and leading role by making them growth-oriented so that they could provide an impetus to further expansion. They have to be broad-based, comprehensive, specially related to the problems of the industry and consistent with the overall industrial policy.* The industry needs some fiscal incentives which may be in the form of excise rebates, regular supplies of raw materials especially cane and, above all, a rational price-policy related to its actual cost conditions. In the long run, steps have to be taken to raise technical efficiency through a well phased renovation and modernisation programme so that cost increases due to deteriorating efficiency could be checked. In the massive scheme of financing, the reserve utilisation by the mills has to be adequately supplemented by the financial assistance by lending institutions and commercial banks.

Once the efficiency standard, cost conditions and pricing policy permit the realisation of normal profits by the industry, the Government can go ahead with its plans for a wider distribution network and a higher proportion of controlled sugar in the total production, in the interest of price stability. This, however, presupposes better organisational efficiency and matching transport facilities. It is, therefore, only an integrated approach that can bring the modern sugar industry to a path of stability and sustained growth.

* *The Economic Times*, March 30, 1980. The cost schedules for the industry were last recommended by the Tariff Commission in its Report in 1973 based on data of 1971-72 for three seasons ending 1974-75.

REFERENCES

1. Deer, Noel, *The History of Sugar*, vol. 1, London 1949; Mac Kenna, Sir James, The Indian Sugar Industry, *Journal of Royal Society of Arts*, vol. LXXVII, No. 3970, Dec. 21, 1926; and Hurt, B. C., The Indian Sugar Industry, JRSA Vol. LXXXIII No. 4318, August 16, 1935.
2. Mac Kenna, Sir James, *The Indian Sugar Industry.* It is reported that manufacturers could extract only 60% of the juice of the sugarcane with the existing technology. Loss due to evaporation was significant. Due to lack of linkage between various processes there was substantial wastage in conversion of sucrose into glucose.
3. Quoted in Gadgil, D. R., *The Industrial Revolution of India in Recent Times, 1860-1939.* Delhi : Oxford University Press, 1972.
4. Report of the Indian Tariff Board on Sugar Industry, 1937.
5. Indian Tariff Board, Govt. of India, Delhi, 1938-39, Vol. IIIB.
6. Hirsch, Leon V., *Marketing in an Underdeveloped Economy : The North Indian Sugar Industry.* N. J. : Englewood Cliffs, 1961.
7. Adarkar, B. N., *The History of Indian Tariff*, 1924-39, New Delhi; Government of India, 1940.
8. According to Indian Sugar Mills Association, the total output during the first four months of the season, was 20,60,000 tonnes as against 24,12,000 tonnes during the corresponding period last year.
9. *The Economic Times*, March 4, 1980. It has been reported that out of 244 factories, 71 closed down.

Productivity
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Paint Industry

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Paint industry is ideal as a small scale industry in India as capital requirements in terms of machinery is small whereas the ratio of volume of sales to investment is high. Long term plans for the development of the industry need to be drawn up to achieve self reliance in paint and also to produce surplus for export.

A world without paints would be a world without most metals, a weather beaten world and a world without beauty. The paint industry has demonstrated its ability to make the world attractive during the past 5000 years and is destined to make even greater contribution to our civilisation in the future. West Europe and North America are amongst the world's most important producers of paint. America's paint industry is worth thousand million dollars and West European industry has 2000 firms employing 1,25,000 workers. The present consumption of 5.5 million tonnes of paint in West Europe could progressively rise to 7.00 million tonnes by 1990 Demand for paints in India according to Union Industry's Guidelines for Industries is likely to rise to 2.09 lakh tonnes in 82-83. Total investment in the industry is around Rs. 10 crores and current production at 1.45 lakh tonnes is valued at Rs. 45.50 crores. Indian paints manufacturing and paint application methods are by and large as good as those prevailing in the technologically advanced countries because of the access to the technical information possessed by their British counterparts who control a dominant share of Indian paint production.

While the requirement of paints were almost entirely imported before the first world war the present demand is entirely met by domestic production. Import of paints is prohibited. The Indian paint industry comprises 900 manufacturers out of which 17 are in the organised sector contributing 50 percent of the total output of paints. The rest are in the small sector distributed all over the country. The organised sector

is now wholly indigenous and units with foreign holdings have brought these holdings to less than 40 percent. There is a regional balance with regard to production. The emergence of the small sector as an equal with the organised sector meets the small sector orientation of the Government policy. The paint industry is basically a service industry and labour intensive in contrast to less labour intensity and greater automation of its foreign counterpart. Almost all process equipments for paints are indigenously manufactured except for large sized attritors and large sized dispersing equipment. Only 5 per cent of raw materials consumed by paint industry is imported. Paint industry is ideal as a small scale industry in India as capital requirements in terms of machinery is small where as the ratio of volume of sales to investment is one of the highest in the chemical industry. The value of raw materials used in the paint industry is 40 to 45 per cent for resins, 30 per cent for pigments and 10 percent for solvents. India is self sufficient in aromatic solvents. India holds a monopoly in the shellac used in the manufacture of white paint. Estimated exhaustion rates of zinc and lead vary between 1990-2000 AD for both. Indian Standard Institute has laid down standards for more than 210 interior and exterior ready mixed paints and Indian technology has developed efficient processing for enhancing the drying rate of oils, water resistance and colour retentivity in the entire spectrum of paints used in the country.

Demand for paints and varnishes follows closely industrial growth in general and the country's construction activity in particular. The low per capita consumption of 230 gms of paint in India as compared to 18,020 kg in US, W. Germany and Japan is a reflection of the leeway the industry has to make. One of the constraints in the widespread use of paints is their high prices. Paint is still mainly an urban phenomena in India with rural areas content to be in the 80 per 'lime wash' age. Raw materials cost about 70 to of the cost of the product. The main raw material Titanium dioxide rutile is still imported costing Rs. 7 crores annually constituting 80 per cent of our import bill comprising sophisticated and speciality coatings. A major portion of Indian paint export comprises white paints to Russia containing high proportion of imported rutile pigment which narrows the commercial profit margin. Short and erractic supply of imported raw materials aggravates this constraint. The quality of rutile locally manufactured by Travmer Titanium Products (TTP) is not of international standard. Kalmark Chemicals Kalyam West Bengal in the private sector with an annual capacity of 135000 tonnes and Kerala Minerals and Mining Corporation in the public sector with an annual capacity of 22000 tonnes and using foreign technology will pave the way for independence of the industry from imported raw materials. Inferior grades of oil like castor oil can be used in making paints as abroad. Cheap oils like castor oil, tung oil, tobacco seed oil, etc are replacing, linseed oil preferred for its superior drying quality, due to widespread use of the latter for edible purposes particularly in Madhya Pradesh and Maharashtra. Almost 35 to 40 percent of the cost of paints consists of taxes and levies not only on finished materials but also on raw materials through their built up cost placing it on par with luxury industries though in fact it is a priority industry. Cost of industrial paint is an important factor in the marketing of paints as it is a raw material which would materially affect the production costs and manufacturer's competitive ability in the market. The potential for long range growth of paint industry is on industrial finishes. Because of the non availability of flow metres paint manufacturers find difficulty in putting the exact quantity of liquid resins and solvents in a mixing tank. Our engineers must concentrate on making good quality flow metres for optimising pigment consumption. This is not the requirement of paint manufacturers alone but also of a large number of other chemical industries. In advanced countries spectrophotometres hooked to minidigital computers give perfect colour matching from batch to batch and lead to economy in consumption of pigments.

Paint export is highly competitive where one can hold one's own only through raising productivity of manpower, procuring raw materials at international prices and developing alternative sources of raw materials within the country. The Development Council should draw up long term plans for the development of the industry on the above lines to achieve self reliance in the product and also to produce surplus for export. Only 5 per cent of our production is exported. The productivity rates abroad are high 57.5 tonnes per employee in Italy and about half as much in UK and Ireland. In a climate of rising costs of raw materials and labour it is important to maintain high output per man hour and make more

efficient use of raw materials like using thinner coatings on tin covers and alkyd resins which are rated good on tin covers and asbestoscement. We will have to serve markets for specialised materials like container coatings, marine paints, anti-corrosive coats, traffic marking paints, artist's colours, bituminous paints, fungical coatings and fire retarding paints. While massive attempts are being made to standardise both raw materials and finished formulations there is always what is known as special in the case of pigments used in paints, printing works, paper coatings, rubber and plastics. There is much to learn in this respect from abroad and to see to what extent R&D can make their contribution for making the role of the small sector useful and substantial in the economy. The industry abroad is concentrated in transnational corporations as well as being integrated forwards and backwards to a considerable degree producing standardised products with sophisticated machinery to cope with increasing labour costs and energy problems We should therefore concentrate on raising our productivity particularly in specialised and small paints for export markets. Quantity wise specialised paints are the least important but are the most highly priced materials on the market.

Industry sponsored campaigns promote paint consciousness generally stimulating internal consumption and saving of wastage caused by forces of erosion. Some of the progressive companies could make joint efforts for increased usage of paint in the country, particularly in the rural areas by developing cheap coatings. Foreign exchange should be made available for promotional expenses for export drive. We could increase our exports from 1.20 crores in 1979 to 2 crores in 1980-81 and more in the years to come by mounting aggressive publicity and sales campaigns abroad. There is good potential in the future for those concerns which are prepared to market cheap and quality paints in an active way as opposed merely to supplying to customers on request. We should promote use of paint as do-it-yourself product.

The nature of the paint industry is such that it requires more intensive market research than most other technology based industries. This is because paints serve diverse markets ranging from retail markets to the highly sophisticated industrialised finishing industries. The Central Glass and Ceramic Research Institute Jadavpur has developed a number of paints based on mica. These paints are claimed to be not only cheaper than conventional ones but have better storage properties and improved performance. They are anti-corrossive and may be used for roadmarking and as fire retardant paint. The National Development and Research Council will provide the know how for the manufacture of the paints against a payment of royalty. An economic unit for mica based paint is 10,000 litres per annum and the industry can be set up in the small sector. India is rich in mica resources, being the largest exporter of mica in the world and has achieved a high degree of expertise in mining, grading and marketing of this mineral. The geological survey of India has informed about the existence of considerable quantities of good red oxide and red earth in the Bellary-Hospet area of Karnataka. If a regular and economic supply of thinners and extenders like linseed oil, tung oil, mineral spirits, etc. from the adjoining Andhra Pradesh is available and a local market assured it should be possible to start a factory on moderate scale for the manufacture of red pigments. Tungabhadra Dam site area with numerous buildings, abundant supply of water, easy transportation by rail and road would be an ideal place for location of the paint industry.

The paint industry has a bright future in India. Paint technologists are bending their energies to trimming raw material costs. At present oil bound distempers are most popular and 80 per cent of paints in India are based on alkyd resins reserved for small sector and exempted from tax. The share of sophisticated coatings like plastic emulsion is small and needs to be enlarged. Raw material used in India consist of 40 per cent vegetable oils, 40 per cent resins and monomers and 20 per cent minerals. Expansion of oil seed production is under way. Adequate feed stocks from Bombay High, etc are available and there is sufficiency of mineral wealth in India comprising ilmenite micaeous iron oxide, etc. The evolution of a more modern and more technologically sophisticated paint industry in India will make it a power in world markets, turning out products based on low material costs and aimed at new customers looking for products that are non-pollutant, durable, energy cheap, authentic, aesthetically pleasing and unique. Besides, there will be even distribution of incomes and vastly varying tastes in products, services and styles—

an interesting projection of perspectives in the paint industry carrying a message of considerable importance to India.

Production costs in the paint industry can be lowered by closer attention to purely technical personnel processes under the supervision of a technician directly independent of the dictates of the laboratory. He should concentrate on two areas, namely, a simplification of laboratory formulas backed by expert knowledge of the properties of pigments, extenders and additives specially those of wetting agents such as lenithin and a more effective use of machinery. Grindometres commonly result in false measurements. A microscopic examiner or the Garmsen method for pigment particle size determination is fraught with fewer errors. The required fineness of grind must be considered. Poor Pump performance often leads to fluctuating and declining output. Waste in filling and packing can be eliminated by automatic systems for large quantities. The advanced technology that is now available in the country can effectively serve the needs of our paint industry and be utilised in preserving for posterity, the attractive monuments, temples and other antique structures that dot the length and breadth of India and are in various stages of dilapitation. Indian paint industry should exploit the opportunities for expansion in both types of organic coatings decorative as well as industrial that are available at present.

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Constraints to Productivity Increase in Potato Farms in Nilgiris

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This study highlights the effects of positive attitudes of potato farmers towards new, appropriate technology and the reason for non-adoption of improved farming practices. The reasons include inadequate and untimely availability of High Yielding Varieties and quality seeds, micronutrients and credit facilities. Excessive use of fertilizer also contributed to increased cost of cultivation.

One of the most important tasks facing the country is that of fighting malnutrition among the vulnerable sections of the society. India's nutritional problems are mainly inadequacy of calories and over dependence on cereals as a source of calories. One way of providing nutrition is to provide protein at low cost and in acceptable form. Potatoes, having a high nutritive value and superior quality protein, have the potential of forming a viable subsidiary food crop in India to remove the nutritional imbalances. It is now increasingly recognised by nutritional experts that about 6 kgs of annual per capita consumption of potato in India should be increased to a much higher level. The experts agree that potato in processed form constitutes a comparatively less expensive and acceptable source of protein.

Potato is an established staple food in various forms in our country and one of the major crops, with annual production of 6,171,100 tonnes from an estimated area of 594,000 ha in 1978-79. Tamil Nadu ranks seventh among potato producing states in the country with the Nilgiris District, which is selected for the study, occupying 67 per cent of potato area in the state. The economy of the district mainly depends on potato production. The time series data on potato production and productivity of the district indicated that the productivity was increased to 48 per cent during a period of 10 years. Though productivity has been increased, the experimental station yield and demonstration yield data showed that poten-