NATIONAL PRODUCTIVITY COUNCIL

Productivity

Vol. 45 January–March 2005 No. 4

Focus : Food Processing Industry

Paradigm Shift in Food Industry

Efficiency in the Indian Food Processing Industry

Managerial Effectiveness Through IT

Gender and ICT

Constraints in Work Environment

Corporate Governance of Management Institutions

IPM Technology on Cotton Productivity

Productivity of Wheat

Oyster Mushroom Production in Karnataka

Guidelines for Contributors

Scope and Coverage

PRODUCTIVITY is the principal journal of the National Productivity Council of India. The Journal aims at disseminating information on concepts of and data on productivity and its growth in India and elsewhere. It also aims at disseminating knowledge on techniques and methods of productivity improvement through effective management of all types of resources. Thus, contributions from a large spectrum of disciplines are accepted for publication. Only those manuscripts that present the results of original research and analysis are acceptable to the Journal. The managerial/policy implications of the study should be highlighted separately towards the end of the paper.

Format of Manuscripts

Contributions should be of about 5,000 words length. Tables, illustrations, charts, figures, exhibits etc. should be serially numbered and typed in separate pages and should not be mixed with the main text. The text should be addressed to the Editor, **PRODUCTIVITY**, National Productivity Council, Utpadakta Bhawan, Lodi Road, New Delhi-110 003.

About the References

Only those references which are actually utilised in the text should be included in the reference list. In the text, references should be cited with the surname of the author(s) alongwith the year of publication and the page number, all in brackets. If there are more than one reference by the same author during any year, the year may be subscripted with 'a' or 'b'. For instance, reference may be given at the end of the sentence as: (Szendrovits, 1988a, p. 337). Sources of data need to be given below each table unless otherwise mentioned in the text. Reference list should be alphabetically arranged. Each reference should carry the surname of the author, followed by other names, the title of the paper in quotes, the name of the journal underlined, volume and issue numbers and the year of publication. In the event of a book, the title should be followed by the publisher's name and year of publication. In the event of a report from an organisation, the name of the organisation may be cited in the place of the author.

Accompanying Material

The manuscripts should be accompanied by:

1. An abstract of the paper not exceeding 100 words.
2. A declaration that the paper is original and has not been submitted elsewhere for publication.
3. A note about the author(s) not exceeding 50 words.

Subscription

Inland	:	Annual Rs. 1200 Single Copy Rs. 300
Foreign	:	Annual Airmail US $ 100 Annual Surface Mail US $ 90 Single Copy Airmail US $ 25
SAARC Countries	:	Annual Airmail US $ 50 Annual Surface Mail US $ 45 Single Copy Airmail US $ 15

Productivity will be sent to all subscribers within each quarter. The Journals Division, CBS Publishers & Distributors, may be contacted in the event of non-receipt within one month from the quarter.

All business correspondence to be addressed to:

The Journals Division,
CBS Publishers & Distributors,
4819/XI, Prahlad Street
24, Ansari Road, Daryaganj,
New Delhi 110 002.

Tel. : 23289259, 23266861, 23266867
Fax : 91-11-23266838, 23276712
E-Mail : cbspubs@del3.vsnl.net.in

ISSN 0032-9924

Productivity

A QUARTERLY JOURNAL OF THE NATIONAL PRODUCTIVITY COUNCIL

Vol. 45 • January–March 2005 • No. 4

CBS PUBLISHERS & DISTRIBUTORS
New Delhi • Bangalore (India)

CBS PUBLISHERS & DISTRIBUTORS

NEW DELHI : 4819/XI, Prahlad Street, 24 Ansari Road
Daryaganj, New Delhi-110 002

BANGALORE : Seema House, 2975, 17th Cross
K.R. Road, Bansankari IInd Stage
Bangalore-560 070

ISSN 0032-9924

Published on behalf of the National Productivity Council by S.K. Jain for CBS Publishers & Distributors, 4819/XI, Prahlad Street, 24 Ansari Road, Daryaganj, New Delhi 110 002. Typeset by Pagitek Graphics, 7F West Guru Angad Nagar, Laxmi Nagar, Delhi and printed at Daksha Printing Pvt. Ltd., 7/11 Ansari Road, Daryaganj, New Delhi-110 002.

Printed in India.

Production Director: Vinod Jain

Contents

Technical and Scale Efficiency in the Indian Food Processing Industry ... 511
—*Jabir Ali & Sanjeev Kapoor*

From Quantity to Quality: Need for a Paradigm Shift in the Food Industry ... 519
—*Satish Y. Deodhar*

The Standards and Labeling Requirements in the Indian Food Industry ... 527
—*Padmaparna Dasgupta*

Changing Trends of Technological Research in Post-Globalization India ... 534
—*Binay Kumar Pattnaik*

Diagnosis and Initiatives for Improving Competitiveness: A Case of SME ... 543
—*Rajesh K. Singh, Suresh K. Garg & S.G. Deshmukh*

Managerial Effectiveness Through IT ... 552
—*V. Nanda Mohan & V. Ajayakumar*

Gender and ICT: Towards an Analytical Framework ... 558
—*C. Vijaya*

Effectivity of Knowledge Transfer Through Expatriate Professionals ... 565
—*M.K.D. Rao & S.C. Rastogi*

Constraints in Work Environment—An Empirical Study of Research Groups in India and China ... 572
—*Anju Chawla*

Corporate Governance of Management Institutions: The Total Quality Way ... 580
—*Vijaya Bandyopadhyaya & Ashis K. Pani*

Review of Privatisation of Electricity Distribution in Orissa ... 590
—*Sasmita Palo & Sweta Panigrahi*

Relative Rating Model for Justification of Competitive Supply Chain ... 600
—*Rambabu Kodali & Srikanta Routroy*

Industrial Utilization of Sorghum in India: An outlook ... 610
—*B. Dayakar Rao, K.A. Bharath Kumar & Binu Mathew*

Total Factor Productivity and Productions Function Analysis for Organic and Inorganic Chemical Industry in India ... 618
—*A. Vijayakumar & M. Krishnaveni*

The Scope of JIT Implementation ... 628
—*Sanjay Sharma & D.K. Singh*

Perspectives of TQM in Indian industries ... 634
—*Raj Kumar, Dixit Garg & T.K. Garg*

Simulated Annealing Algorithm for Mixed-Model U-shaped Line Balancing Problem ... 642
—*K. Venkatasubbaiah & T.S.A. Surya Kumari*

Objectives in Single Machine Scheduling ... 648
—*Pankaj Chandna & S.K. Sharma*

Decision-making Model for Economical Wastepaper Collection ... 654
—*Rupesh Kumar Pati, Prem Vrat & Pradeep Kumar*

Application of Taguchi's Robust Design Approach for Hospital Services in India ... 660
—*Roma Mitra Debnath & Ravi Shankar*

Impact Evaluation of Integrated Pest Management (IPM) Technology on Cotton Productivity in Punjab ... 667
—*Nirmal Singh, Sukhpal Singh & Satwinder Singh*

Input-Use Productivity of Wheat Crop in Different Agro-climatic Zones of Punjab ... 674
—*N.S. Dhaliwal, D.K. Grover & R.S. Bawa*

Input-output Relationship in Oyster Mushroom Production in Karnataka ... 681
—*Mamatha Girish, M.V. Srinivasa Gowda, M.R. Girish & Lalith Achoth*

Book Reviews ... 687

News & Notes ... 692

Technical and Scale Efficiency in the Indian Food Processing Industry

Jabir Ali & Sanjeev Kapoor

Food processing is one of the emerging sectors of Indian economy and has been identified as a thrust area for socio-economic development. This study evaluates the performance of the food processing industry and role of technology in the acceleration of growth. Input-oriented variable returns to scale (VRS) DEA model has been used for measuring technical and scale efficiency.

Jabir Ali is assistant professor and Sanjeev Kapoor is associate professor, Agriculture Management Centre, Indian Institute of Management, Lucknow.

Food processing is a sunrise industry of the Indian economy and has been identified as a thrust area for development due to its vital linkage effect. India has immense potential for production and export of various food items because of sufficient resources, available markets and favourable business environment. Food processing sector covers a wide range of food items like meat and meat products, fish and fish products, fruits and vegetables, vegetable oils and fats, milk and milk products, grain milling, animal feeds, confectionery products, bakery products, sugar processing etc.

Demand for food items has undergone a profound change during the last two decades due to increase in population, per-capita income, urbanization, change in food habits and awareness about health and nutrition (Kumar, 1998; Bhalla et al, 1999; Chand, 2003). The demand for horticultural and animal-based products is more price and income elastic than cereals (Dastagiri, 2004). The consumption pattern in both rural and urban households have diversified over time towards packaged food products, fruits and vegetables and animal-based products.

The level of food processing in India shows ample potential to be realized. Most of the food items are basically consumed in fresh form and very meagre quantity is further processed for value addition. But in recent years, demand for branded processed food products is gaining momentum. As per a study conducted by McKinsey and the Confederation of Indian Industry (CII), the turnover of the total food market is approximately Rs. 250,000 crores (US $ 69.4 billion) out of which value-added food products comprise Rs. 80,000 crores (US $ 22.2 billion). This has led to increased investment in food processing.

The structure of the Indian food processing industry reflects that food production is mainly constrained due to lack of productivity augmenting technologies as the major quantity of food products are being produced in

the unorganized sector, where resource utilization is very limited. Even organized food processing units are also facing various kinds of challenges which have emerged due to the opening up of the economy in the recent decade. To meet the emerging challenges, there is an urgent need to bring efficiency in production process through either maximizing the output or minimizing the cost. Therefore, technology is the key for improvement in growth and efficiency in the food processing sector.

Empirical evidences on contribution of technology to growth of food processing industry are scarce. However, the evidences from food industry as a whole indicate varied contribution of technology to growth of food processing industry (Goldar, 1986; Ahluwalia, 1991; Mitra et al., 1998; Mitra, 1999; Goldar and Kumari, 2002; Trivedi et al., 2002 and Pattnayak and Thangavelu, 2003). The present study evaluates the performance of the food processing industry and role of technology in acceleration of growth of this industry and will provide feedback to industries as well as policy makers to redesign the strategies to maximize benefits of our rich and varied agricultural wealth. The technical and scale efficiency of Indian food processing industry is measured by input-oriented variable returns to scale (VRS) DEA model.

Data and methodology

The data on input and output related to registered/organized food manufacturing units is compiled from the Annual Survey of Industries published by the Central Statistical Organisation, Ministry of Statistics and Programme Planning, Government of India. Input oriented variable returns to scale (VRS) DEA model is used to measure technical and scale efficiency in the Indian food processing industry. The input-output variables used include capital, labour, raw material consumed, fuel consumed, and gross value of output (Table 1). The efficiency scores are obtained by using DEAP software (version 2.1) developed by Coelli (1996). The non-parametric approach introduced as Data Envelopment Analysis (DEA) by Charnes, Cooper and Rhodes (1978) is a method of measuring efficiency of Decision Making Units (DMUs)/firms through linear programming techniques, which 'envelop' observed input–output vectors as tightly as possible (Boussofiane et al., 1991).

The original model developed by Charnes, Cooper and Rhodes (CCR model) was applicable when technologies were characterized by constant returns to scale (CRS). It is assumed that there are 'N' *DMUs* with K inputs and S outputs on each DMU. That is, DMU_j ($j = 0, 1, ..., N$) consumes x_{ji} amount of input i and produces y_{jr} amount of output r, where $x_{ji} \geq 0$ and $y_{jr} \geq 0$. The constant returns to scale (CRS) DEA model is only appropriate when the firm is operating at an optimal scale (Coelli et al., 1998).

Table 1: Variable definitions used for measuring efficiency scores

Variables	Units	Definitions
Output (y)	Rs. lakhs	Gross Output is defined as ex-factory value of products and by-products manufactured during the accounting year.
Capital (x_1)	Rs. lakhs	Users cost of capital i.e., a sum of depreciation, interest payment and rent is used to estimate the capital use in food processing industry (Kumbhakar and Heshmati, 1996)
Labour (x_2)	Rs. lakhs	The Annual Survey of Industry provides two categories of labour employment in food processing industry i.e. employees and workers. The data available on payment to employees and workers is used in the study.
Raw Material (x_3)	Rs. lakhs	Raw material, the major input used in food processing, basically constitutes raw agricultural produce of respective food units like meat, spices, edible oils, vegetables, chemicals, ice and packing materials etc.
Fuel Consumed (x_4)	Rs. lakhs	Fuel is measured in values/costs of different types of energy, and mainly includes electricity, diesel and petrol used in food processing units

Source: Central Statistical Organization, GoI, New Delhi

In the method originally proposed by Charnes, Cooper and Rhodes (1978) relative efficiency of the *DMUs* can be measured by the input-oriented DEA model as:

$$\min_{\theta, \lambda} \theta,$$

subject to

$$Y_{rj}\lambda_j \geq Y_{r0}$$

$$\theta X_{i0} - X_{ij}\lambda_j \geq 0$$

$$\lambda_j \geq 0$$

Where;

X_{ij} = the amount of the i^{th} input at DMU_j,

Y_{η} = the amount of r^{th} output from DMU_j,

θ = the input technical efficiency (TE) score,

λ_j = vector of weight which defines the linear combination of the peers of DMU_j

The value of θ gives efficiency score for a particular *DMU*, which satisfies $0 \leq \theta \leq 1$. The *DMUs* for which $\theta < 1$ are inefficient while for $\theta = 1$ are on frontiers and hence efficient.

Various factors affecting production process may cause a *DMU* not to operate at optimal scale (Coelli, 1996) and therefore, Banker, Charnes and Cooper (1984) extended the CCR model to account for technologies that show variable returns to scale (VRS). The Banker, Charnes and Cooper (BCC) model can be developed by adding the convexity constraint to the constant returns to scale (CRS) linear programming problem.

i.e. $$\sum_{j=1}^{N} \lambda_j = 1$$

$$\lambda \geq 0$$

The CRS technical efficiency scores can be decomposed into pure technical efficiency and scale efficiency. This can be done by applying both CRS and VRS DEA on the same model. The difference between CCR model and BCC model can be illustrated in Figure 1. We shall assume one input and one output situation.

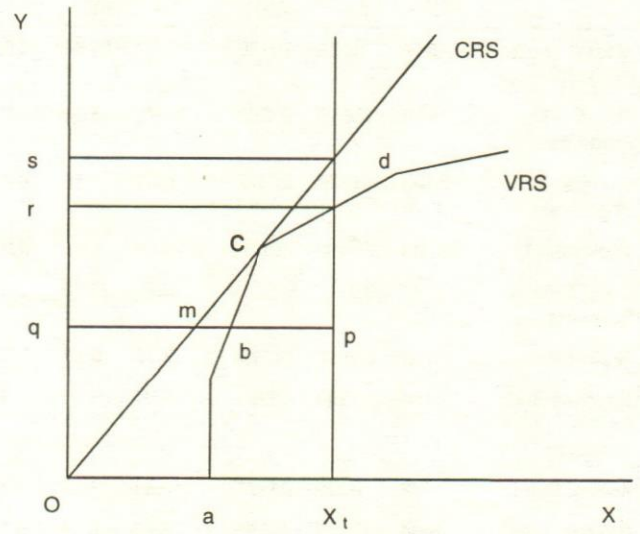


Fig. 1. CRS, VRS and Scale Efficiency

The inefficient *DMU* is represented by the point P. Under the input orientation model, the technical inefficiency of *DMU* 'P' is *mp* in CRS and *bp* in VRS. The difference between these two measures is expressed as scale inefficiency (SE). In ratio form, technical efficiency in CRS is *qm/qp* and in VRS it is *qb/qp*. Scale efficiency is *qm/qb*. Thus, technical efficiency (TE) obtained from CRS can be decomposed into 'pure' technical efficiency and scale efficiency. The point such as 'c' on the frontier is scale efficient. The concept of scale efficiency constitutes two technologies i.e. constant return to scale (CRS) and variable return to scale (VRS). The scale efficiency measure corresponding to input X_t is given by:

$$\text{Scale Efficiency} = \frac{(Oq/Or)}{(Oq/Os)} = \frac{Os}{Or}$$

Performance of food processing in India

Food processing is an emerging sector of the Indian economy and is growing at a rate of more than 10 per cent per annum. A majority of the food processing units in the country are unorganized and facing various kinds of challenges in the fast changing global scenario. About 46 per cent of the organized manufacturing units are agro-based out of which 17 per cent are food processing units. Table 2 shows the growth in number of food processing units in the country over the last two decades. The annual growth in total number of food processing units has increased from 0.91 per cent during 1980-90 to 1.56 per cent during 1990-2001. The magnitude of growth varies significantly across various categories food processing units and over the time period.

Table 2: Number of Food Processing Units in India, 1980-2001

Category	Number of Units			ACGR (%)		
	1980-82	1990-92	1999-2001	1980-90	1990-2001	1980-2001
Meat & Meat Products	25	32	49	1.42	3.94	3.01
Fish & Fish Products	223	196	290	−2.67	4.06	1.96
Fruits & Vegetables	164	217	462	3.04	7.93	4.93
Vegetable Oils	3336	3261	2871	−0.68	-1.35	−0.03
Dairy & Dairy Products	269	469	798	5.18	6.10	5.87
Grain Milling	7106	9564	11278	2.90	1.89	2.47
Starches and Starch Products	325	330	674	−0.99	8.13	3.69
Animal Feeds	146	278	475	4.98	5.80	6.48
Bakery Products	534	734	931	3.83	2.76	3.11
Sugar (Indigenous/ Refined)	2386	1334	1075	−5.97	-2.44	−4.30
Confectionery	87	143	256	5.46	5.72	5.44
Other Food Items	2819	3066	3537	0.51	1.56	1.46
Total Food Products	17421	19626	22695	0.91	1.64	1.58

Source: Annual Survey of Industries (various issues), CSO, New Delhi

Some of the segments in the food processing industry have experienced higher growth during the 1990s as compared to the 1980s, like starch and starch products (8.13%), fruits and vegetables (7.93%), milk & milk products (6.10%), animal feed (5.80%) and confectionery (5.72%). The number of entrants in the animal-based food products is also showing a very significant growth mainly due to the increased consumer demand for animal based products in most food diets. These trends show that economic reform and liberalization policy have fueled the growth processing in most of the food segments by encouraging investment in the food processing industry. Food processing units where the growth has come down over time are grain milling and bakery products. The vegetable oil and sugar processing units are experiencing negative growth in number mainly due to lack of policy support. The vegetable oil units are unable to sustain themselves in the market due to cheap inflow of edible oil import, whereas growth in sugar processing units are constrained due to multiple regulatory framework in the domestic market.

Table 3: Number of Persons Employed in Food Processing Units in India, 1980-2001

Category	Number of Persons			ACGR (%)		
	1980-82	1990-92	1999-2001	1980-90	1990-2001	1980-2001
Meat & Meat Products	3474	3509	3984	–1.23	2.12	1.71
Fish & Fish Products	11210	15959	26237	0.17	5.99	5.69
Fruits & Vegetables	11946	14898	22018	2.55	5.03	3.75
Vegetable Oils	112054	111324	118497	–0.43	0.77	0.70
Dairy & Dairy Products	38234	61805	88450	4.79	4.15	4.51
Grain Milling	177007	232598	290549	2.87	3.08	2.88
Starches and Starch Products	8591	10540	10713	0.06	0.11	1.35
Animal Feeds	5564	12047	20154	7.00	7.06	7.67
Bakery Products	21274	33380	44767	5.28	3.92	4.00
Sugar (Indi genous/Refined)	594119	346909	251123	–6.44	–4.04	–3.24
Confectionery	3603	8984	11952	7.99	3.51	6.59
Other Food Items	307148	276468	310855	–2.57	1.33	1.01
Total Food Products	1294224	1128421	1199299	–2.26	0.82	0.48

Note: ACGR = Annual Compound Growth Rate using exponential growth model

Source: Annual Survey of Industries (various issues), CSO, New Delhi

Food processing is an important employment generating activity within the agriculture sector and India has vast scope for its development (Gupta, 2002). Table 3 shows employment pattern in various food processing units over the last two decades. The annual employment growth in the food processing industry was negative to the extent of 2.26 per cent during 1980-90, which has become positive to the extent of 0.82 per cent during 1990-2001. Most of the food processing segments are showing very significant growth in terms of employment during the 1990s. For example, animal feed processing segment shows highest growth in employment to the extent of 7.06 per cent per annum during 1990s followed by fish and fish products (5.99%), fruits and vegetables (5.03%) and milk and milk products (4.15%). The employment opportunities in almost all food segments have increased over the decade except sugar processing units, which is showing negative growth in employment. These trends in employment growth show that food processing can not only increase income through value addition but also can create potential employment opportunities in the country.

Table 4: Gross Value Added in Food Processing Units in India at 1993-94 prices, 1980-2001

Groups	Value in Rs. lakhs			ACGR (%)		
	1980-82	1990-92	1999-2001	1980-90	1990-2001	1980-2001
Meat & Meat Products	849	3031	10136	8.67	14.64	16.03
Fish & Fish Products	1963	10616	21000	14.70	6.20	13.79
Fruits & Vegetables	1196	4579	22972	6.01	11.06	8.40
Vegetable Oils	25262	71410	128213	10.04	8.99	9.97
Dairy & Dairy Products	9244	35975	145819	12.86	9.15	8.28
Grain Milling	18162	53362	140931	7.10	9.41	8.35
Starches and Starch Products	2134	4299	19951	4.64	9.21	7.61
Animal Feeds	1672	8160	21977	7.34	7.60	7.82
Bakery Products	4954	17823	45255	7.90	8.08	8.17
Sugar (Indi-genous/ Refined)	56507	145315	347403	16.76	10.79	14.18
Confectionery	796	6532	29558	14.23	9.58	12.82
Other Food Items	32034	105636	171587	10.75	4.97	7.13
Food Industry	154772	466737	1104802	10.08	8.03	8.97

Source: Annual Survey of Industries (various issues), CSO, New Delhi

Table 5: Cost Composition of Food Processing Industry in India (%)

Groups	Wages & Salaries			Cost of capital			Material Consumed			Fuel Consumed		
	1980-82	1990-92	1999-2001	1980-82	1990-92	1999-2001	1980-82	1990-92	1999-2001	1980-82	1990-92	1999-2001
Meat & Meat Products	9.45	7.66	4.74	6.93	8.81	8.79	78.40	78.04	81.03	5.22	5.49	5.44
Fish & Fish Products	2.95	2.41	3.37	4.29	4.24	5.22	90.43	91.06	88.15	2.33	2.29	3.25
Fruits & Vegetables	8.32	10.99	8.19	8.22	13.45	15.68	79.70	69.42	68.54	3.76	6.14	7.59
Vegetable Oils	1.76	1.53	1.79	2.38	3.17	3.61	93.17	92.16	91.02	2.69	3.14	3.58
Dairy & Dairy Products	4.88	4.93	4.90	2.97	3.43	3.99	88.22	88.32	87.60	3.93	3.31	3.50
Grain Milling	3.24	2.43	2.43	3.09	3.61	3.56	92.02	91.82	91.13	1.65	2.15	2.88
Starches and Starch Products	6.21	6.16	6.41	7.75	10.09	11.38	72.36	69.16	69.56	13.68	14.59	12.65
Animal Feeds	3.77	3.08	3.26	3.26	2.58	3.40	91.02	92.33	90.67	1.95	2.01	2.67
Bakery Products	8.93	9.00	9.25	3.73	4.82	4.65	82.76	81.15	79.71	4.58	5.03	6.39
Sugar (Indigenous/Refined)	9.55	9.51	8.66	10.88	10.88	15.15	76.46	77.11	74.33	3.11	2.49	1.85
Confectionery	7.99	7.93	8.98	5.15	10.32	9.65	83.20	76.82	75.61	3.66	4.94	5.76
Other Food Items	6.74	5.52	6.84	3.71	5.05	5.30	83.95	84.29	81.84	5.60	5.14	6.01
Food Industry	5.03	4.57	4.79	4.82	5.36	6.59	86.95	86.93	85.10	3.20	3.15	3.52

Source: Calculated from Annual Survey of Industries Data, CSO, New Delhi

The value addition through the food processing industry in the country is growing at a very significant rate over the last two decades. The trends of gross value added in the Indian food processing industry are given in Table 4. Though the rate of growth in gross value added from food processing industry was 10.08 per cent during 1980-90, this has slightly declined during 1990-2001, but still the growth is as high as 8.03 percent. The growth in value addition for most of the food processing segments have gained during the 1990s like meat and meat products, fruits and vegetables, grain processing, starches and starch products, animal feeds and bakery products. The growth in output for meat and meat products and fruits and vegetables are almost doubled during last two decades. These growth trends in gross value added for various food products suggest that there is vast scope for value addition.

Efficiency in Indian Food Processing Industry

The demand for processed food products are expected to grow faster with sustained economic growth, rising per capita incomes, strengthening urbanization trends and increasing awareness of the nutritive value of food items. These opportunities can be capitalized for the benefit of producers as well as consumers and would largely be determined by the pace of development and diffusion of the technologies in the food processing industry. At present the food processing industry in India is dominated by small scale producers. For bringing synergies in food processing industry, it is now time to restructure the food chain from production to consumption, keeping in mind the various kinds requirements of the industry for improving its efficiency and performance.

Table 5 shows cost composition of the food processing industry in India, which would definitely help in formulating effective strategies to develop the food segment. The table suggests that the major cost of the food processing industry is material which accounts for about 85 per cent of total processing cost. The major constraints in development of food processing industry are timely and quality procurement of raw material i.e. agricultural produce for processing which accounts for about 85-90 per cent of material cost. The absence of assured electric supply coupled with lack of other infrastructural facilities like road, transport, storage etc are other constraints which hinders growth in food processing.

Though cost composition in various types of food processing units vary, material consumption constitutes the major share. The analysis of composition over the last two decades shows that there is some diversifica-

Table 6: Average Technical and Scale Efficiency in the Indian Food Processing Industry

Group	1980-90			1990-2001			1980-2001		
	CRSTE	VRSTE	SCALE	CRSTE	VRSTE	SCALE	CRSTE	VRSTE	SCALE
Meat & meat products	0.08	0.78	0.11	0.68	0.93	0.72	0.41	0.86	0.44
Fish & fish products	0.17	0.92	0.19	0.78	0.89	0.85	0.50	0.91	0.54
Fruits & vegetables	0.14	0.85	0.17	0.58	0.92	0.62	0.38	0.89	0.41
Vegetable oils & fats	0.23	0.97	0.23	0.74	0.97	0.76	0.50	0.97	0.51
Dairy & Dairy Products	0.16	0.84	0.20	0.61	0.93	0.64	0.40	0.89	0.43
Grain Milling	0.27	0.96	0.27	0.66	0.95	0.70	0.48	0.95	0.51
Starches & Starch Products	0.08	0.61	0.13	0.38	0.73	0.47	0.24	0.68	0.31
Animal Feeds	0.20	0.81	0.26	0.63	0.87	0.71	0.43	0.84	0.49
Bakery Products	0.21	0.88	0.24	0.71	0.95	0.74	0.47	0.92	0.51
Sugar (indigenous & refined)	0.15	0.86	0.18	0.69	0.88	0.76	0.44	0.88	0.49
Confectionery	0.08	0.77	0.11	0.52	0.79	0.62	0.32	0.79	0.39
Others	0.28	0.93	0.30	0.74	0.95	0.78	0.53	0.94	0.55
Food Processing	0.17	**0.85**	**0.20**	**0.64**	**0.90**	**0.70**	**0.43**	**0.88**	**0.47**

Note: CRSTE = Technical Efficiency from CRS DEA
VRSTE = Technical Efficiency from CRS DEA
SCALE = Scale Efficiency

Source: Calculated from Annual Survey of Industries Data, CSO, New Delhi

tion in cost composition towards various factors of production like labour, energy use and capital. The share of labour cost in aggregate food processing units has slightly declined from 5.03 per cent in 1980-82 to 4.79 per cent in 1999-2001, whereas share of capital has increased from 4.82 per cent to 6.59 per cent during the same period. The share of energy consumption has also increased showing technological change in food processing industry.

The performance of the Indian food processing industry is measured in terms of technical and scale efficiency (Table 6). The technical efficiency is the product of its scale efficiency and pure technical efficiency estimated under the assumption of constant returns to scale. The values of efficiency indices equal to unity implies that the industry is on best-practice frontier while values below unity shows that the industry is below the frontier or is technically inefficient. The average technical efficiency score is estimated to be 0.43 under the CRS model and 0.88 under the VRS model. The average scale efficiency in Indian food processing units for the entire period is estimated to be 0.47. The analysis indicates that the average technical inefficiency could be reduced by 12 per cent by improving scale efficiency and eliminating pure technical inefficiencies.

The efficiency scores in the food processing industry vary significantly across type of food processing units and over time. During the 1980s, the average efficiency under the CRS and VRS technologies were 0.17 and 0.85 respectively, which have improved to the extent of 0.64 under the CRS model and 0.90 in case of the VRS model during 1990s. The scale efficiency also improved from 0.20 to 0.73 during the same period. Scale efficiency scores suggest sizeable deviation from scale of operation during the 1980s, but it has approached to unity over time. Technical efficiencies in almost all categories of processing units have improved over time but still there is vast potential to improve the processing efficiency.

The analysis of input slacks in the food processing industry suggests that the industry is labour intensive and the effects of expansion of food industry on labour employment and productivity appears to be favourable. The raw material which constitutes about 85 per cent of the production cost, is basically raw agricultutral produce which is also inefficiently used (Table 7). There are a number of intermediaries acting between the producers and the processors. Food processing units are often located in the urban areas and thus the transportation cost of raw material is high.

Promoting Farm Industry Interface

The food processing industry has not taken much initiative to strengthen backward linkages with the farmers/producers and largely depends on the intermediaries for its requirement of raw materials. There-

Table 7: Average Slacks in Input use in Indian Food Processing Industry

Group	1980-90			1990-2001			1980-2001		
	Fuel (Rs. lakh)	Material (Rs. lakh)	Cost of capital (Rs. lakh)	Fuel (Rs. lakh)	Material (Rs. lakh)	Cost of capital (Rs. lakh)	Fuel (Rs. lakh)	Material (Rs. lakh)	Cost of capital (Rs. lakh)
Meat & meat products	702	20060	1000	182	7496	732	401	12912	850
Fish & fish products	111	3022	176	13	333	36	63	1681	108
Fruits & vegetables	159	4444	287	13	637	62	86	2550	177
Vegetable oils & fats	1	62	0	0	25	0	1	45	0
Dairy & Dairy Products	119	3180	178	11	391	30	66	1789	106
Grain Milling	0	9	0	1	18	3	1	14	2
Starches & Starch Products	76	1786	80	10	282	0	44	1033	40
Animal Feeds	303	7535	542	29	811	26	166	4161	284
Bakery Products	4	127	4	5	156	7	5	135	6
Sugar (Indigenous & refined)	5	161	6	5	157	9	5	159	8
Confectionery	159	4765	243	24	672	57	91	2635	148
Others	7	200	11	2	32	0	4	111	5
Food Processing	137	3779	210	25	918	80	78	2269	144

Source: Calculated from Annual Survey of Industries Data, CSO, New Delhi

fore, proper methods of sourcing quality raw material for food production should be adopted for shortening the supply chain of food processing industry. The supply chain for agricultural commodities is quite long and disorganized, causing losses to both farmers and processing industries. The farmers are not getting full remuneration for their produce due to multiplicity of middlemen, lack of demand and supply information, high post-harvest losses, non-availability of adequate infrastructural facilities and disorganized agro-processing industries in the region. Moreover, agro industries have to face problems related to timely and adequate delivery of raw material of good quality for utilizing processing capacity in an efficient manner. The supply chain can be shortened by introducing the contractual model to strengthen the farm-industry interface.

Table 8: Contract Options in Indian Food Processing Industry

Sl. No.	Options to farmers to sell the agriculture produce	Options to Industry to procure the agriculture produce
1.	Sale in Spot Market	Purchase from spot market
2.	Sale through commission agents	Purchase through commission agents
3.	Sale through farmers' cooperatives	Purchase through farmers' cooperatives
4.	Direct sale to industry under contract farming	Direct purchase from farmers under contract farming
5.	No involvement of farmers	Own raw material under captive farming

There may be five types of contractual options to arrange farmer-industry interface in agricultural commodities as given in Table 8. The choice of a contractual interface between the two parties hinges on whichever alternative minimizes the transaction costs involved in contracting. Such costs include not only the direct costs of information, negotiation and communication, but also the indirect costs of monitoring and enforcing the terms and conditions of the contract.

It is a given fact that no single option can smoothly be applied under all circumstances, nor is any single option any superior to the others from the view point of both the parties. Therefore, designing the institutional mechanisms to develop suitable farm industry interface in India is the need of the hour. While organizing a suitable interface between the farmers and industry, the interest of both the parties needs to be protected. From the farmers' point of view, the relevant institutional arrangement must ensure not only the sale of produce at a reasonable price, but also hedging against input, output and income risks. Since the raw material in the form of agriculture produce constitutes the lion's share in total cost of production in the agro-processing industry, protection of industry interests in this context demands timely supply of quality raw materials in the required quantity at reasonable prices.

Suitability and sustainability of any option largely depends upon the kind of negotiations between the agro-industry and the farmers. Under the purchase of

raw materials in the spot market, the firms incur large expenditure on information costs, particularly in a place where marketed surplus per farmer is small (as the firm has to contact a large number of farmers to purchase its required quantity). The problem becomes compounded when there is uncertainty over market prices and arrivals in terms of quantity and quality of the produce. In spite of all these drawbacks, large quantities of agricultural produce are transacted in India through unregulated spot markets, where there is hardly any permanent relationship between the industry and the farmers.

In order to minimize the transaction cost, most agri-business firms hired a large number of commission agents to act as facilitators between the firms and the farmers. But these commission agents are invariably involved in interlinked transactions with the small and marginal farmers and exploit them to the maximum possible extent. Accordingly, this option may not be advocated as it does not ensure protecting the interests of the farming community. Farmers' cooperatives may replace the commission agents and simultaneously protect the interest of farmers. It can allow the agri-business firm to develop interface with the farmers at much lesser costs. Unfortunately, the current state of affair with most of the cooperative marketing societies does not raise many hopes for this alternative too.

The option of contract farming brings the industry into direct contact with the farmers, and this can exercise control over the quantity, quality and price of raw materials. This option is also favourable to small and marginal farmers, over sale of produce to a spot market either directly or through commission agents or through inefficient cooperatives. This option can work so long as both the parties are honouring the terms and conditions of the contract. If the contract does not have sufficient contingency plans and easy but strict enforcement devices, the agro-industries may face a problem of procurement when the farmers find market prices more attractive than contract prices. The industry has to incur a lot of other costs to make the farmers loyal to the firm.

To develop suitable interface between the industry and the farmers in our country, there is a need to promote a partnership web between the two. The nature of transaction should be symbiotic in nature which can provide sufficient incentives to both the parties to operate on the same level. The recent experiments of 'e-Chaupal' promoted by ITC and 'Kissan Kendra' by Tata Rallis are welcome steps in this direction. The same spirit is very much required to build organizations that can provide a stable and sustainable interface between the farmers and the agri-business companies.

References

Ahluwalia, I. J. (1991): "Productivity and Growth in India Manufacturing", Oxford University Press, Delhi.

Bhalla, G.S. and Peter Hazell (1998): "Foodgrains Demand in India to 2020: A Preliminary Exercise", Economic and Political Weekly, Vol. 32 (52): A150-A154.

Boussofiane, A.; R. Dyson and E. Thanassoulis (1991); "Applied Data Envelopment Analysis", European Journal of Operational Research, Vol. 52, pp. 1-15.

Chand, Ramesh (2003): "Government Intervention in Foodgrain Markets in the New Context", Policy Paper 19, National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi.

Charnes, A.; Cooper, W. W. and Rhodes, E. (1978): "Measuring the Efficiency of Decision Making Units", European Journal of Operational Research, Vol. 2, pp.429-444.

Coelli, Tim (1996): "A guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program", CEPA Working Paper 96/08, Centre for Efficiency and Productivity Analysis, Department of Econometrics, University of New England, Australia.

Dastagiri, M.B. (2004): "Demand and Supply Projections for Livestock Products in India", Policy Paper 21, National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi.

Goldar, B.N. (1986): "Productivity Growth in Indian Industry", Allied Publishers, Delhi.

Goldar, B.N. and Anita Kumari (2002): "Import Liberalisation and Productivity Growth in Indian manufacturing Industries in the 1990s", Working Paper Series No. E/219/2002, Institute of Economic Growth, Delhi – 110 007.

Gupta, S.P. (2002): "Report of the Special Group on Targeting Ten Million Employment Opportunities over the Tenth Plan Period", Planning Commission, Government of India, New Delhi

Kumar, P. (1998): "Food Demand Supply Projections", Indian Agricultural Research Institute (IARI), New Delhi.

Mitra, A. (1999): "Total Factor Productivity Growth and Technical Efficiency in Indian Industries", Economic and Political Weekly, Review of Industry and Management, July 31-August 6.

Mitra, A; A. Varoudakis and M. A. Vegarzones (1998): "State Infrastructure and Productive Performance in India Manufacturing", Technical Paper No. 139, Organisation for Economic Co-operation and Development, Development Centre, Paris.

Pattnayak, Sanja S. and S.M. Thangavelu (2003): "Economic Reform and Productivity Growth in Indian Manufacturing Industries: An Interaction of Technical Change and Scale Economies", Working Paper No. 0307, Department of Economics, National University of Singapore.

Trivedi, P., A. Parkash, and D.Sinate (2000): "Productivity in Major manufacturing Industries in India: 1973-74 to 1997-98", Development research Group Study No. 20, Department of economic Analysis and Policy, RBI, Mumbai. □

From Quantity to Quality: Need for a Paradigm Shift in the Food Industry

Satish Y. Deodhar

Time has come for a paradigm shift in the Indian food industry. Quality enhancement has become imperative due to the opening up of this sector to foreign brands and firms. A multi-pronged approach is necessary to bring about this change, which involves the adoption of statistical quality control tools at the production stage, understanding and incorporating consumer perceptions about different dimensions of food quality, streamlining the existing food laws and harnessing newer technologies.

Satish Y. Deodhar is Faculty at the Indian Institute of Management, Ahmedabad.

The Indian food industry is in a state of flux. Gone are the days when India was considered a food-deficit country. Today, India is self sufficient in food production. In fact, marketed surplus is growing, millions of tonnes of food stocks are accumulating, and India is a leading producer of a number of horticultural products. Moreover, for quite some time now, the importance of value addition in the food sector has received attention, and it is hoped that the food processing sector will grow rapidly. However, over the decades, in pursuit of these objectives, quality consideration has not received the kind of attention it should have. Instances of rotting fruits and vegetables at major APMC markets, poor quality of food stocks rendering them uncompetitive both in domestic and export market, food poisoning and/or recurring adulteration cases, and a general perception that imported products are of a better quality, have been symptomatic of this inattention.

WTO-led trade liberalization has heightened such quality perceptions. For example, a significant amount of value addition is perceived to have gone into imported apples in terms of uniformity of size, shape, colour, and packaging. Similarly, in processed food products, customers are getting attracted to better variety, packaging, and shelf life of foreign brands such as Tropicana, Nestle and Lays, though these products are not necessarily imported. Moreover, trade liberalization has resulted in asymmetric trade opportunities. While low international prices increase imports, high international prices have not necessarily led to increase in exports. On many occasions, poor quality has become a hindrance to export promotion. Rejection of shipments of wheat, shrimp, meat products, peanut (butter), and mangoes on various sanitary and phytosanitary grounds are just a few examples of this. In fact, the WTO agreements on sansitary and phytosanitary measrures (SPS), technical barriers to trade (TBT), and, to some extent, trade related intellectual property rights (TRIPS) have shifted the focus from price competitiveness to quality competitiveness.

Concurrently, Indian customers are also becoming more demanding in terms of quality. A reasonable per capita GDP growth rate, increased workforce participation by women, changing lifestyles, and a heightened awareness about hygiene and nutrition have contributed to this change. In this context, survival and success in domestic and global markets have become a challenge for food processing firms, horticulturists, and farmers alike. And, therefore, it has become imperative that there is a paradigm shift in the thinking of agribusiness stakeholders, including policymakers, to concentrate efforts on understanding what food quality is, how consumers perceive it, how to control and enhance it, and, what are its global benchmarks.

Dimensions of Food Quality

The concept of food quality can be looked at from various perspectives. The first is how to maintain and improve quality at the production stage. Second, it is important to understand how quality is perceived by consumers so that agribusiness firms can make changes to their products to suit their preferences. Third, which is more relevant for policy makers, is the institutional perspective: Food, like other products, not only gives material pleasure, but is necessary for maintaining a healthy lifestyle for the population. Therefore, food safety and nutrition issues are extremely important to policymakers. Finally, food quality is undergoing changes due to phenomenal changes in technology. For example, introduction of genetically manufactured (GM) foods holds good prospects for the future, although they are presently banned in India.

All these perspectives on quality revolve around different dimensions of quality. Garvin (1988) talked about various dimensions of quality in the context of non-food products in general. One can extend those dimensions to food products as well. *Conformance* is the degree to which a product meets the pre-established standards. There are all kinds of specifications that need to be adhered to for food products. These specifications may involve a permissible range of variation for a particular parameter or an inequality norm for it. For example, there always will be a permissible range of acidity level and salt concentration for pickles that maintain a standard taste and prevent spoilage as well. Control charts can be used to monitor conformance to the specifications. Similarly, Codex standard for maximum permissible level of aflatoxin in groundnut is 15 ppb, much less than the Indian standard of 30 ppb. In fact the European Union standard is less at 5 ppb, creating a non-tariff barrier to Indian groundnut exports.

Performance refers to primary operating characteristics of a product. For example, *ceteris paribus* Basmati must be aromatic rice, which gives the typical enhanced aroma when cooked. Similarly, an ice cream that melts faster than a competing brand would be ranked lower on performance dimension. *Features* are the secondary characteristics that supplement a products basic functioning. Instant coffee powder sold in glass jars, which can be used later for storing kitchen items, or orange juice in tetra-packs enhancing convenient use are examples of the features dimension of food products.

Reliability reflects the probability of a products malfunctioning or failing within a specified period of time. This dimension is applicable more to durable food items than items consumed instantly. A brand of pickle that has a higher chance of getting spoiled compared to other brands within a specified period, will rank lower on this dimension. *Durability* means amount of use one gets from a product before it physically deteriorates. Durability in the context of food products reflects its shelf life. *Safety* is one of the most important dimensions of food quality. If a food item is spoiled, its safety dimension is easily recognisable. However, food products can contain microbial, toxic and/or physical contaminants, which are not recognisable before consumption. The consumer either falls sick after consumption of a food product or the long-term effects of repeated consumption of a product could be hazardous to health.

Safety is one of the most important dimensions of food quality.

Aesthetics are important in the sense that how a product looks, feels, tastes and/or smells is clearly a matter of personal judgement and a reflection of consumer preference. Nevertheless, there appears to be some uniformity in consumers ranking of products on the basis of aesthetics. Study by Bonner and Nelson (1985) shows that high quality of food was most often associated with attributes such as rich/full flavour, tastes natural, tastes fresh, good aroma and looks appetizing. Another dimension is the *Perceived Quality*. Consumers do not always possess all information about the product attributes. Hence, perceptions of quality in terms of images, advertising and brand names become critical. For example, a consumer may perceive that tetra-packed juice sold by Dabur is made in India, but it is in fact manufactured in Nepal.

And then there are some other dimensions of food quality that have become relatively important in recent times. Nutrition is one such dimension. Although tradi-

tional dietary practices did address this issue through holistic food habits, lifestyles are changing traditional food habits, and the nutrition aspect is now revisited through modern scientific findings. Another dimension is Product Origin, and *Method of Production* which are valued both by consumers and producers. A Hapus (Alphonso) mango, Basmati rice or French wine has to come from a particular geographic location, and, importance is attached to the way the product is made or processed. This quality attribute has assumed importance because the Trade Related Intellectual Property Rights Agreement (TRIPS) of the WTO has underscored the importance of protecting such geographic signs of food products. A related quality attribute is the ability to reproduce itself. Agricultural commodities have the ability to reproduce themselves through use of their own seeds. With intellectual property rights being increasingly protected, some limitations have arisen on farmers right to use seeds for the next crop.

A sum total of all these dimensions of a food product represent the quality of that product. Among the quality dimensions mentioned above, *conformance* to standards is clearly a production related dimension, and *aesthetics* is a dimension which is very much consumer-centric. Quality can be improved by better production processes, better understanding of consumer preferences, a better regulatory framework, and judicious use of changing technology.

Managing Food Quality

Production Perspective

In the quest for quantitative goals, quality aspect has been somewhat ignored in the food industry. No doubt food processing firms, horticulturists, and farmers, based on their accumulated wisdom, are best placed to judge the good production practices in their operations. However, there are some simpler ideas that could be shared with them as an extension activity, which have the potential to improve their product quality and profits. For example, on-farm cost-benefit studies show that a *mandava* method of tomato cultivation is much better than *para* method, and, grading of tomatoes do give higher actual profits to farmers (Deodhar, 2001). The proposition sounds elementary, however, co-opting a farmer for demonstrating this by taking the produce to wholesale market drives home the point. Similarly, the statistical concept of acceptance sampling can be effectively used for accepting/rejecting produce lots. With the advent of contract farming, such practices do hold a lot of promise, the benefits of which are too obvious to food processing firms procuring the agricultural produce.

It is always in the best interest of a food processing firm to produce good quality products. Else, a single bad event can cause customers to desert. Recent examples of substantive loss of sales for Cadbury and soft-drink manufacturers due to quality problems are cases in point. Cost of quality can be divided into two categories. One is the failure cost, and another is the prevention cost. Whereas the failure cost consists of cost of lost sales, inspection, rework and disposal; prevention cost consists of cost of employing quality management systems in production. As depicted in Figure 1, as one moves towards zero-defect production practices, failure cost comes down but prevention cost goes up. The prevention cost for a zero-defect situation will be extremely high and impractical. However, as suggested in the diagram, total cost of quality can be minimized by introducing threshold level of quality management systems. Introducing production control charts for processed foods, acceptance sampling methods for fresh produce, and, employing logical food safety and quality systems like Hazard Analysis and Critical Control Points (HACCP) can be such threshold quality management practices and system (Deodhar and Dave, 1999).

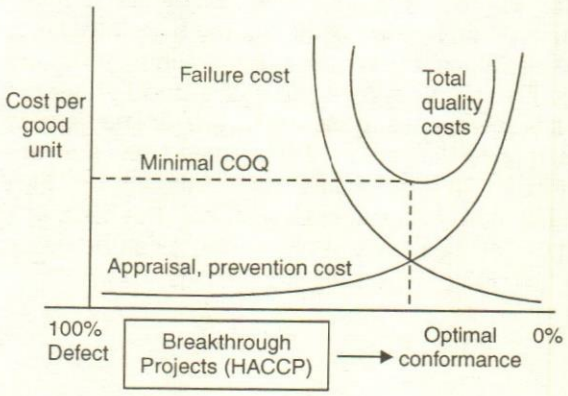


Fig. 1 Minimizing the Costs of Quality

Is implementation of food safety and quality system such as HACCP expensive? A study by Deodhar (2003a) shows that in food processing firms, annualised average expense of the HACCP system is less than 1 per cent of the turnover. In fact, there are significant scale-economies in its use. Implementation of HACCP was suggested by Codex Alimentarious Commission more than a decade ago, and it has been endorsed by the SPS agreement of WTO. Unlike in the United States and European Union, where HACCP has been incorporated into their domestic food laws, HACCP is not mandatory for Indian food processing companies. Indian food law needs to incorporate HACCP as a mandatory requirement for food processing companies. In the case of foodgrain and horticultural crops, implementation of HACCP may be difficult; however, its logical concepts can very well be applied.

Valuing Consumer Perceptions

In the post-WTO regime, international trade in food and agribusiness has exhibited intra-industry character where similar goods are being traded. Significant growth in intra-industry trade implies that in the domestic market there will be intense competition between foreign brands and domestic brands. In such a market, while price competitiveness would matter, firms would increasingly focus their attention on differentiating their products from those of others. Product differentiation and branding is possible if firms build up the quality competitiveness of their food products. And, building quality competitiveness implies identifying various quality dimensions of a given product, understanding consumers perceptions about these dimensions, and, making adjustments to the product based on these perceptions. One of the techniques to evaluate consumer perceptions is called the hedonic price analysis.

The basic assumption of the hedonic price analysis is that utility is enhanced not by the consumption of a good per se but by the quality dimensions of that good. In this context, Rosen (1974) presented a model of product differentiation based on the hypothesis that any good is valued for its utility generating quality dimensions. Therefore, market price of a good is the sum of the shadow prices consumers are willing to pay for each quality dimension. The demand function derived from maximising consumer utility function provides the foundation for hedonic price analysis. The hedonic price function for the i^{th} brand of a product can be described as a function of its quality dimensions:

$$Pg_i = Pg\ (z_{i1},...,z_{ij},...,z_{in}), \qquad ...(1)$$

where $z_1, .z_n$ are product quality dimensions. The utility maximization problem for a representative individual can be formulated as:

$$\text{Max } U=U\ (X,Z) \quad \text{s.t.} \quad M - Pg_i - X = 0, \qquad ...(2)$$

where X is a composite, numeraire commodity and M is income. An implicit assumption is that each individual purchases only one unit of the product in a given period. Applying first order condition for the choice of characteristic z_j we get:

$$\frac{\delta U/\delta z_j}{\delta U/\delta X} = \frac{\delta Pg}{\delta z_j} \qquad ...(3)$$

Equation (3) is nothing but stating the law of equi-marginal utility for the numeraire good X and the characteristic z_j. $\delta Pg/\delta z_j$ is the marginal implicit price for characteristic z_j and corresponds to the regression coefficients when estimating equation (1). Further, the utility function U can be rewritten as:

$$U = U\ (M - Pg_i, z_{i1},...,z_{ij}, ...,z_{in}). \qquad ...(4)$$

Inverting equation (4) and solving for Pg_i with z_j as a variable and U* and z^*_{-j} being held constant at their optimal values associated with problem in (2), we can write a bid curve Bj as follows:

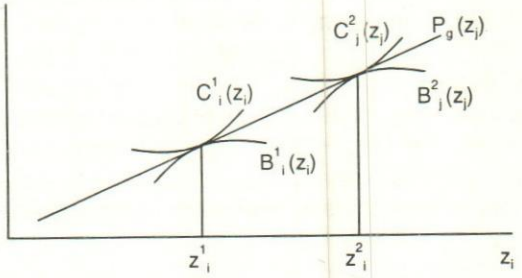
$$B_j = B_j\ (z_j, z^*_{-j}, U^*) \qquad ...(5)$$

Holding other things at the optimal level, (5) describes the maximum amount an individual would be willing to pay for a unit of the product as a function of z_j. A well-behaved bid curve is ought to exhibit a diminishing willingness to pay with respect to z_j. Based on their individual preferences and/or incomes consumers can have different bid curves $B_j^1\ (z_j)$ and $B_j^2\ (z_j)$ as shown in Figure 2.

On the supply side as well, firm's cost of production depends on the quality dimensions of the product. Offer curve for the characteristic z_j derived from the firm's cost function can be represented by:

$$C j = C_j\ (z_j, z^*_{-j}, \pi^*) \qquad ...(6)$$

Equation (6) explains the minimum price a firm would accept to sell a unit of ghee as function of z_j, holding other attributes and profit at the optimal level. Offer curves $C_j^1\ (z_j)$ and $C_j^2\ (z_j)$ for two individual producers are also shown in Figure 2. Now, the equilibrium condition is that bid and offer curves for all quality attributes and for each market participant must be tangent to the Hedonic Price Function $Pg(z_j)$, which is an equilibrium locus for all individual bid and offer curves. Thus, based on this analysis, equation (1) can be estimated and the coefficients and the significance of



Adapted from Schamel, Gabbert and Witzake (1998).

Fig. 2. Bid & Offer Curves and Hedonic Price Line*

* Adapted from Schamel, Gabbert and Witzake (1998).

the independent variables can describe the relative importance of different quality dimensions.

Studies based on this analysis have been conducted quite routinely in other countries where sufficient relevant data are generated for various agricultural commodities and processed foods. For example, Chen, Ethridge, and Fletcher (1997) had undertaken such a study for cotton, and Schamel, Gabbert and Witzke (1998) for wines. In India, very few studies have been conducted that identify the quality dimensions and the consumers perceptions and valuations. For example, a study based on hedonic price analysis of ghee (Deodhar and Intodia, 2002), shows that consumers value the flavour of ghee much more than other quality dimension. Similarly, consumers value the aroma and colour of tea over other quality dimensions (Deodhar and Intodia, 2004). Such studies can help firms to alter their products to suit consumer preferences. Domestic food industry could pay attention to undertaking such studies to develop strategic food quality management practices. However, to conduct such studies, relevant data needs to be generated. Non-government organizations such as Consumer Education and Research Centre (CERC), Ahmedabad, have been generating such data over the last few years.

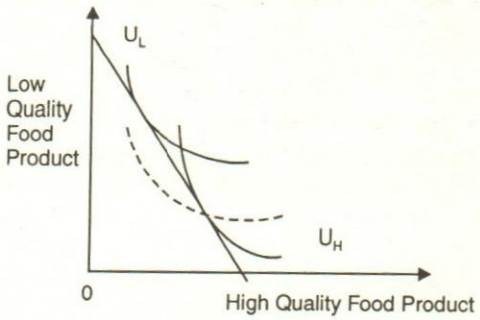


Fig. 3. Choice of Food Quality under Perfect Information

Institutional Perspective

If one were to address the food quality issue as a standard neo-classical economics problem, then one will have to leave this problem to markets alone, and, there is no scope for any regulation by government. For, in a full information environment, producers may produce various kinds of quality foods and consumers are expected to choose the precise quality combinations that maximise their satisfaction. Figure 3 presents this standard neo-classical argument. Consumer H prefers a high-quality food item and consumer L prefers a low-quality item as reflected in their respective indifference curves UH and UL. Given the prices of the two types of quality foods, consumers make their optimum choices. Forcing either of them to choose the quality combination chosen by the other would lead to lower satisfaction. Henson and Traill (1993) and Viscusi, Vernon and Harrington (1995) give such arguments based on food safety considerations.

However, the limitation of the above analysis can be explained by drawing the distinction between search goods, experience goods and credence goods (Nelson, 1970, 1974; Darbi and Karni, 1973). As shown in the classification of goods in Figure 4, for search goods, consumers can determine a products quality before they buy it by examining the product. i.e., they have full information about the product before consumption. The neo-classical analysis can hold good in this case. For experience goods, consumers cannot determine the quality until they buy and use the products. Here, if goods are of repeat-purchase nature, where choice is

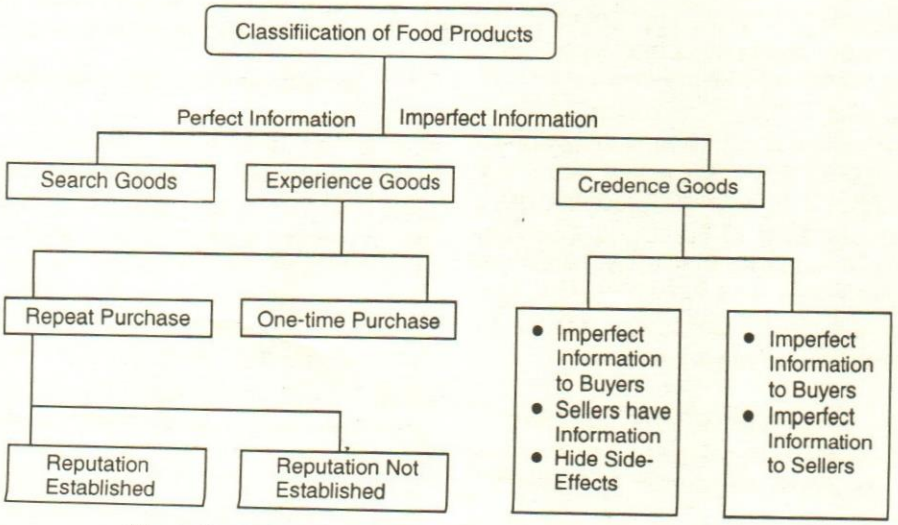


Fig. 4. Quality Information Based Classification of Food Products

based on prior experience with product quality, the market may take care of itself. High quality food producers can charge higher prices to signal high quality. Thus, market imperfection may be overcome by repeat purchases, build-up of a firm's reputation and higher prices.

However, there is a moral hazard problem for producers if they sell experience goods without warranty to one-time consumers. A fly-by-night milk vendor may adulterate milk with urea. If you fall sick the next day, it is your bad luck, for you do not know how to locate the vendor. More importantly, food items can also be classified as credence goods where consumer information stays imperfect both before and after the purchase. Many times consumers cannot establish for sure the cause and effect relationship between contamination and ill effects on health. A producer may know the quality of a good but consumers cannot discern quality both before and after the purchase. For example, adulteration and chronic effects of low-level exposure to toxins can be dangerous in the long-run. Another possibility is that both producers and consumers have imperfect information about the product, before as well as after the use. One could say in principle, conspiracy theories notwithstanding, that the contamination of edible oil with Argemone oil in 1998 may not have been a purposeful act, but that ignorance of economic agents on both sides of the market caused the dropsy-related deaths.

The overriding consideration in the above analysis is the safety attribute of foods. Due to experience and credence nature of food products, markets cannot handle this issue by themselves, and hence, institutional intervention becomes necessary. In India, there is a well established institutional structure for regulating food quality. It is a three-pronged structure that includes food laws, food standards and ministries implementing the laws. First, there are many central acts including Essential Commodities Act, 1955; Agriculture Produce (Grading and Marketing) Act, 1937; Prevention of Food Adulteration Act (PFA), 1954; and Export Quality Control and Inspection Act, 1963. There are a few more, and then there are state-level acts as well. Secondly, many ministries such as the Ministry of Food and Civil Supplies, Ministry of Food Processing Industries, Ministry of Agriculture, Ministry of Health and Family Welfare, Ministry of Commerce, Ministry of Consumer Affairs, are involved in the implementation of various laws.

Thirdly, there are a number of food standards in existence. The PFA standard is set and revised by the Central Committee for Food Standards. PFA law and standards are mandatory in India. The Agmark standard defines quality of cereals, oilseeds, oils, butter, ghee, legumes, eggs and many other products. These standards are not mandatory until the commodity is included in the compulsory certification list by the central government. Moreover, the Bureau of Indian Standards (BIS) is the national standards organisation for India, responsible for laying down standards for all products. These standards again are not mandatory standards. Similarly, many product orders such as Fruit Product Order (FPA) exist that define standards for a specific agricultural sector.

This institutional structure, however, has become too unwieldy. There are a multiplicity of food laws ministries controlling these laws and food standards. Many times, the administrative authority of various ministries that implement the laws overlaps. The laws themselves need to have a modern worldview. For example, only the Prevention of Food Adulteration Act specifies what additives are permitted in a food product. Therefore, if any new additive, which is perfectly safe, is added to the product, it becomes a case of adulteration. Moreover, the degree of adulteration is not the basis for conviction. Infact the offence and the punishment are the same irrespective of whether the adulteration is great or small. Also, inadequacy of manpower for effective implementation of the laws is also an issue. Another important dimension that Indian food laws ignore is nutrition labelling. Time has come for packaged food products to have nutrition labelling that informs consumers on nutritional parameters of that food as a percentage of daily recommended allowances. Foreign brands have already initiated this practice in India.

Time has come for packaged food products to have nutrition labelling that informs consumers on nutritional parameters of that food as a percentage of daily recommended allowances.

Efforts have also been made at the international level to address the food safety concerns. To minimise the occurrence of unfair trade restrictions, two agreements relevant to food regulations were signed under the WTO accord. These are the Agreement on Sanitary and Phytosanitary Measures (SPS) and Agreement on Technical Barriers on Trade (TBT). The SPS agreement aims at eventual harmonisation of national food standards with international standards, guidelines and recommendations. For food products, the guidelines of the Codex Alimentarius Commission (CAC) have been endorsed by the WTO. Similarly, for exchange of plants and animals, the guidelines of International Plant Protection Convention (IPPC) and International Office of

Epizootics (IOE) have been endorsed. The SPS agreement has a loophole in that article 3.3. of SPS that allows countries to have standards higher than the codex standards. This has created a potential for non-tariff barriers to trade. It also must be noted that on many occasions, codex standards for heavy metal and pesticide residues are much stricter than Indian standards. In this context, there is a considerable scope for quality improvement in Indian agricultural products. The TBT agreement deals both with food and non-food products on issues related to their size, shape, packaging, labelling, handling safety, and environmental issues. For example, if an Indian food product is exported to United States, it will have to have weight labelling in ounces and pounds. Similarly, imports to India should have weight labelling in grams and kilograms. That we see foreign food products in Indian markets with weight labels in ounces and at times in non-Indian languages, is an indication of implementation problem at our end.

Quality and Technological Change

Research conducted in laboratories across the globe, both in food science departments and in R&D segments of firms, are generating newer ways of processing and preserving foods. In a globalized market such changes will be adopted quickly in India by foreign and domestic food companies. For example, as an ongoing process Indian regulatory authorities will have to test the newer food additives in domestic conditions, and incorporate them in the domestic food law(s). The same applies to levels of newer forms of pesticide residues and microorganisms.

The last couple of decades have witnessed significant advances in biotechnology research. Crop improvement using biotechnology and genetic engineering is already a reality in some countries. India is one of the few developing countries with scientific infrastructure, human resources and the capability to exploit biotechnology for the benefit of society in general and the farming community in particular. Although India has banned the use/import of genetically modified (GM) foods at this time, scientists are either ready for field trials or are at different stages of development of GM crops. India might have achieved food security, but nutrition security still eludes her. A possibility of superior nutritional quality of GM foods assumes considerable significance. Development of golden rice, a variety of rice that has higher levels of vitamin A is a case in point. Another important aspect of biotechnology is that it has opened up new avenues for reducing post harvest losses, minimal use of pesticides and lower perishability. Processed foods made from such produce will have lower pesticide residues and higher shelf life.

A possibility of superior nutritional quality of GM foods assumes considerable significance.

The potential for quality improvement in agriculture due to changing technology has, however, generated newer sets of concerns that need to be addressed. Biotech firms are trying to patent their inventions and justly so. Article 27.3(b) of the TRIPS agreement allows for patenting inventions that use genetic material as also the traditional knowledge of a community. India does not have a product patent law yet, however, to fulfil the WTO commitments she has to enact the law urgently. While doing so, provisions must be made in this law to protect the traditional knowledge of communities which at times is used freely by the biotech firms. The protection may be in the form of disclosure of the biological resource and traditional knowledge used, and, evidence of prior consent to use the traditional knowledge and its benefit sharing. Moreover, in the future, farmers are likely to buy patented better quality seeds from biotech firms. While firms need to be protected from the commercial re-use of the patented seeds, the law should provide for farmers to re-use the seeds on their own farm and for non-commercial purpose. Another issue is of labelling and segregation of GM foods. It is important that consumers be offered a choice through clear labelling of foods. Therefore, GM labelling must become mandatory whenever GM foods are allowed to be sold in India.

Policy Implications

The Indian food industry is going through a transitional phase. India is no longer a food-deficit country. Since the last decade, per-capita growth rate of GDP has also been reasonably good. There is not only a growing demand for value-added processed food products, but also a heightened awareness regarding hygiene and nutrition. Concurrently, with the onset of WTO-led liberalisation, foreign food products are having a relatively easy access to the Indian market. Perceived to be of better quality, foreign brands and products are competing very effectively in the domestic market. These are very challenging developments for the domestic food industry. In this context, a paradigm shift has to occur in the thinking of agribusiness stakeholders, with a strategic focus on quality rather than quantity.

It has to be emphasised that agricultural extension activities need to be strengthened. However, in terms of specifics, one may point out that extension activities

may include training programmes on HACCP concepts for food processors and farmers; demonstrations of acceptance sampling techniques and driving home a point in practical terms, that grading improves both quality and profits for the farmers, and that it benefits food processing firms as well. Promoting training institutions for farm labour and potential workers in the food processing industry, on the lines of Industrial Technical Institutes (ITIs), seems a reasonable proposition. Participants with some high-school background could be given training on basic hygiene and farm operations/food processing techniques. Understanding of consumer perceptions about quality is also equally important. Industry associations and NGOs such as CERC, Ahmedabad, must be encouraged to conduct evaluation of quality perceptions by consumers. This may involve undertaking hedonic price analysis and/or market surveys.

On the regulatory aspects, it is quite evident that the institutional mechanism has become quite unwieldy with a multiplicity of food laws, standards and ministries. In the UK for example, there is a single agency, the Food Standards Agency (FSA), that deals with all the issues related to food safety. All food laws and standards are amalgamated under this single nodal agency (Deodhar 2003b). India needs such a single agency and a comprehensive food law to deal with the issue of food safety effectively. In fact, with changing technology, food safety issues are also changing and the food law needs to reflect these changes. Inclusion of nutrition labelling,

As long as protection is offered to the small farmer, biotechnology has a good potential to improve food quality.

a newer perspective on permissible/non-permissible food additives, and GMO labelling in the event of entry of GMO foods in the markets, are some of the important issues. Finally, as long as some form of protection is offered to the small farmer, biotechnology has a good potential to improve food quality.

References

Bonner, P.G. and R. Nelson (1985), "Product Attributes and Perceived Quality: Foods", in J. Jacoby and J. Olson, eds., Perceived Quality, Lexington Books: Massachusettes.

Chen, C., D.Ethridge, and S. Fletcher (1997), "Textile Manufactures Market Valuation of Cotton Fiber Attributes", Journal of Agricultural and Applied Economics, 29 (1), 185-195.

Darbi, M.R. and E. Karni (1973), "Free Competition and the Optimal Amount of Fraud", Journal of Law and Economics., 16, 67-88.

Deodhar, S. Y. (2001), "Local Tomato Supply Chain: Quality Issues and Economics", a case and video CD on the tomato farm of Mr. Ghanashyam Bhai of Khanderaopura village, Gujarat, Case No. CMA-804, IIM-A.

Deodhar, S.Y. (2003a), "Motivation For and Cost of HACCP in Indian Food Processing Industry", Indian Journal of Economics and Business, Vol. 2, No. 2, December.

Deodhar, S.Y. (2003b), "Strategic Food Quality Management, Analysis of Issues and Policy Options", Oxford-IBH: Delhi.

Deodhar, S.Y. and H. Dave (1999), "Securing HACCP in Agriculture to Build Brand Image (SHABRI) in the Context of WTO Agreements", International workshop on Markets, Rights and Equity: Rethinking Food and Agricultural Standards in a Shrinking World, Michigan State University, November.

Deodhar, S.Y. and V. Intodia (2002), "Does Ghee Sold by Any Brand Smell as Sweet?: Quality Attributes and Hedonic Price Analysis of Ghee", Indian Food Industry, Vol. 21, No.2 (March-April).

Deodhar, S.Y. and V. Intodia (2004), "Whats in a Drink You Call a Chai?: Quality Attributes and Hedonic Price Analysis of Tea", Journal of International Food and Agribusiness Marketing, Vol 16, No.1.

Garvin, D. (1988), "Managing Quality", New York: Free Press.

Henson S. and B. Traill (1993), "The Demand for Food Safety, Market Imperfections, and the Role of Government", Food Policy, 18, 152-162.

Nelson, P. (1970), "Information and Consumer Behaviour", J. of Polit. Econ., 78, 311-329.

Nelson, P. (1974), "Advertising as Information", J. of Polit. Econ., 81, 729-754.

Rosen, S. (1974), "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition", Journal of Political Economy, 82, pp. 34-55.

Schamel, G., S. Gabbert, and H. Witzke (1998), "Wine Quality and Price: A Hedonic Approach", in Global Markets for Processed Foods, edited by Daniel Pick et al.

Viscusi, W.K., J.M. Vernon and J.E. Harrington, Jr. (1995), "Economics of Regulation and Antitrust", 2nd ed., Cambridge, MA: MIT Press. □

The artist belongs to his work, not the work to the artist.

– Novalis

The Standards and Labeling Requirements in the Indian Food Industry

Padmaparna Dasgupta

This article deals with the standards and labelling requirements that are essential in the Indian Food Industry.

Padmaparna Dasgupta is Secretary (Head) Confederation of Indian Food Trade and Industry, New Delhi.

The Legal Structure

The Indian Food Industry is subject to various rules and regulations for the conduct of its operations. Most of these laws regulate the manufacture, distribution, storage and marketing of articles of food. It is noticed that for various articles of food within the Food Industry, there are specific laws concerning the manufacturing, marketing, distribution and sale of specific articles of food.

Some of the laws to which the Indian Food Industry is subject to as are specific sectors within the Food Industry:

1. **Prevention of Food Adulteration Act, 1954:** It is the basic statute intended to protect the consumer against a supply of adulterated foods by laying down certain standards. The Central Committee for Food standards' under the Directorate General of Health Services, Ministry of Health and Family Welfare is responsible for operation of this Act.
2. **Essential Commodities Act, 1954:** Regulates manufacture, storage and distribution of essential commodities including food through a licensing system, but does not include the quality or safety aspects. The objective is basically to ensure safe and hygienic manufacturing processes. This Act is implemented through various Commodity Specific Orders like:
   (a) **Fruit Products Order, 1955:** The order regulates manufacture and distribution of all fruit and vegetable products, sweetened aerated waters, vinegar and synthetic syrups. The license is issued based on the satisfaction of the concerned officer with regard to quality of production, sanitation and hygiene, machinery and equipment and work area standards.

(b) **Oils, De-oiled Meal and Edible Flour Control Order 1967 and Vegetable Products Control Order, 1976:** These orders control the production and distribution of solvent extracted oils, de-oiled meal, edible oil seed flours and hydrogenated vegetable oils (vanaspati). For production and distribution, a license is essential from the Directorate of Food and Civil Supplies, which also regulates the price of vanaspati under the order from time to time.

(c) **Meat Products Control Order, 1973:** It regulates manufacture, quality and sale of all meat products and is operated by the Directorate of Marketing and Inspection and requires compulsory registration of manufacturing units or any business in meat and meat products.

(d) **Milk and Milk Products Order 1992:** It regulates the production, supply and distribution of milk and milk products and requires compulory registration of manufacturing or any business in milk and milk products. The order specifies the sanitary requirements, Certification, packing, marking etc.

3. **Standards of Weight and Measures (Packaged Commodities) Rules, 1977:** These rules lay down certain obligatory conditions for all commodities in packed from with respect to their quantity declaration. Directorate of Weights and Measures under the Ministry of Food and Civil Supplies operates these rules.

4. **Export (Quality Control and Inspection) Act, 1963:** The Export Inspection Council is responsible for operation of this act under which a large number of exportable commodities have been notified for compulsory pre-shipment inspection unless specifically requested by the importer not to do so.

5. **Voluntary Standards:** There are two organisations dealing with voluntary standardization and certificate systems concerning quality parameters in food. They are Bureau of Indian Standards (BIS) and Directorate of Marketing and Inspection (DMI).

Historical Background of Prevention of Food Adulteration (PFA) - The Basic Food Act

The PFA Act

Prior to 1954, food authority in India was local, in the form of local provincial acts. The national law, The Prevention of Food Adulteration Act or PFA Act was enacted in 1954. This is the basic Food Act of the country governing standards, quality and safety, as well as measures to (i) ensure pure and wholesome food, (ii) protect from fraud or deception and (iii) encourage fair trade practices.

The PFA Act has been subjected to amendments in 1964, 1971, 1976 and 1986. In 1986, an amendment to the PFA authorized the participation of consumer organisations in the implementation of the act. Of these, the amendments in 1971 were fairly extensive. In 1976, during a period of food shortages and serious law breaking, the PFA was rigorously strengthened by the closing of loopholes and by the incorporation of severe penalties for violations. The minimum sentence then put into place, which still remains the same, was 6 months in jail. Today, these same harsh penalties seem rather archaic.

Implementation

The Act enforces and implements the sampling and testing system through the food inspectors who occupy a key position in a country's food control service. They are authorized to collect samples for routine or special analysis. They are trained or should be trained to inspect various types of food establishments for compliance with sanitary requirements and hygienic practices. They instruct food handlers and packers in hygienic practices and good manufacturing practices and encourage voluntary compliance. They investigate consumer complaints about the safety and unfitness of foods and other violations of the laws and work with other officials, prepare cases for trial and testify in court. They often participate in consumer education activities.

Food inspectors, on picking the samples according to the sampling procedure prescribed under the law, are required to divide the sample into three parts and send one part to the Public Analyst and two parts to the Local Health Authority under the name of the manufacturer. The Public Analyst appointed at the local level performs the initial tests and analysis. The Public Analyst in the case of finding the product adulterated sends the report to the Local Health Authority at the District level who is authorized to launch prosecutions.

In case of appeal by the aggrieved, the preserved samples of the Local health Authority are sent to the nearest of the four regional Central Food Laboratories (CFL) that exist in the country. In such a situation, the report of the CFL is final and supersedes the report of the Public Health Authority.

Penalties

Subject to the report of the Public Analyst or the CFL, the manufacturer of an adulterated product is subjected to punishment with imprisonment for a term not less than 6 months and may extend to three years and with a fine not less than Rs. 1,000 for minor violations and not less than one year and up to six years with fine of Rs. 2,000 for adulteration.

The Standards

The regulatory framework is controlled by the Central Committee for Food Standards (commonly known as CCFS) constituted under the Act which advises the government on all matters arising out of the administration of this Act and also makes amendments to the Standards and Specifications.

Under the CCFS there are about 10 subcommittees to look into the different issues and products. The subcommittees meet regularly and take decisions on the issues and requests coming from industry and other quarters which, on approval, are referred to the CCFS and on their approval are notified by the government.

The process is very transparent, as each notification by law has to be issued first in a draft form and circulated to all concerned including the industry associations for comment within a period of 60 days. The final notification is issued after taking all the comments into consideration.

The Act does not just specify general standards for each category of products, rather, it lays down individual Standards for most of the common food products being manufactured in India. The standards go into minute details of the manufacturing process and specify the use of various ingredients and additives individually for each product.

Some of the major provisions are as follows:

1. Use of Colors

- Natural colors can be used wherever permitted
- Very few synthetic colors or their mixtures are allowed to be used and those also in specified quantities in limited food items like ice cream, milk lollies, frozen desert, flavored milk, yogurt, ice cream mix powder, biscuits including biscuits wafer, pastries, cakes, confectionery, certain canned fruit products including jellies, jam, marmalade, candied crystallized or glazed fruits, non-alcoholic carbonated and non-carbonated ready-to-serve synthetic beverage etc.
- Addition of all inorganic matters and pigments is prohibited in this Rule except Titanium Dioxide in Chewing Gum.

2. Use of Flavors

- Use of natural flavoring substances and artificial flavoring substances and nature identical substances are defined and listed, which can be used in different food Products.
- The flavoring agents may contain permitted anti-oxidants, emulsifying and stabilizing agents and food preservatives.
- Monosodium glutamate may be added to an article of food under proper label declaration and total glutamate contents should not be more than one per cent.

3. Use of Artificial Sweeteners

- Use of Artificial sweetening agents Saccharin Sodium, Aspartame, and Acesulfame is permitted only in a few food products like, carbonated water, soft drink concentrates, Supari (Scented Betel nut), Pan Masala (a type of mouth freshener also used as an ingredient in Betel leaves).

4. Use of Preservatives

- Class I Preservatives i.e., natural preservatives and the like can be added without any restriction
- Only a few class II preservatives are allowed and can be used according to individual standards.
- Use of combinations of more than one Class II preservative is prohibited
- the preservatives and the food item in which they can be added and the prescribed limited for each product

5. Anti Oxidants, Anti-caking agents, Emulsifying and Stabilizing Agents, Anti-foaming agents, Sequestering and Buffering Agents

- Specific additives under each category are prescribed for specific food items and can be used only in those specific groups, in concentration prescribed for each such group.

6. Poisonous Metals, Crop Contaminants and Naturally Occurring Substances

- Specification on maximum limits of poisonous metals in each type of food products are provided
- The MRLs have been provided for alfatoxins and other natural occurring toxic substances

7. Special declarations are also required to be made for some other specific products such as mixed spices, ice cream, etc., containing starch, fortified salt, surface treated hard cheese, fluid milk etc.

8. Prohibitions on certain food items

There are prohibitions on the sale of the certain items like:

- Cream, which has not been prepared from milk or contains less than 25% milk fat
- Skimmed milk as milk
- Turmeric containing any other substance
- Milk containing added water
- Curd not prepared from milk
- Mixtures of two or more edible oils
- Coffee with any substance other than chicory
- Fruits ripened by acetylene gas, commonly known as carbide
- Coating food articles with mineral oil etc.

The Regulations Governing Import of Food Products

Apart from complying with all the domestic requirements, the importers of food products also need to compulsorily register with the Weights and Measures Authority.

EXIM policy prohibits the import of beef in any form and import of products containing beef in any form. All consignments of and processed food products including edible oils, imported in bulk, shall carry a declaration from the concerned exporter on the shipping documents that the consignment does not contain beef in any form. All consignments of edible products, imported in consumer packs, shall carry a declaration on the label of the package that the product does not contain beef in any form.

The Labeling Provisions

A. Mandatory Labeling Provisions

There are various labeling requirements under different Laws with different objectives

a. Weights and Measures (Packaged Commodities) Rules:

- Name and address of the manufacturer and packer/importer;
- Generic or common name of the commodity packed;
- Net quantity in terms of standard unit of weights and measures. If the net quantity in the imported package is given in any other unit, its equivalent in terms of standard units shall be declared by the importer;
- Month and year of packing in which the commodity is manufactured or packed or imported;
- Maximum retail sale price at which the commodity in packaged form may be sold to the ultimate consumer. This price shall include all taxes, local or otherwise, freight, transport charges, commission payable to dealers, and all charges towards advertising, delivery, packing, forwarding and the like, as the case may be.
- The size of the letters and numerals to be used on the label in proportion to the size of the principal display panel is specified.

b. Environment Protection Act 1986 implementing Rules for the Manufacture, use/Import and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells

- According to this Rule, prior approval of the Genetic Engineering Approval Committee will be required for import, export, transport, manufacture, process, use or sell of any hazardous microorganisms or genetically engineered organisms, substances or cells. Even production processes, in which genetically engineered organisms, substances or cells are generated or used, shall not be commenced without prior approval of the committee.
- All food stuffs, ingredients in food Stuffs and additives, including genetically modified organisms or cells shall not be produced, sold, imported or used except with the prior approval of the Genetic Engineering Approval Committee.

c. Prevention of Food Adulteration Act General Provisions for all Products

- The labels should not contain false statements.
- All packaged food should bear name and complete address of the manufacturer, packer, vendor and importer
- Any food article manufactured outside India is packed or bottled in India; the package containing such food article shall also bear on the label, the name and complete address of the importer and premises of the packing/bottling in India.
- Name and trade
- Name of the product.
- Name of the ingredients in descending order of composition.
- Net weight or volume.
- Distinctive batch number or lot number.
- Month and year of packing.
- The symbol of irradiation and license number (irradiation is allowed only in few select commodities).
- At least one of the languages used for declarations on the label should be English or Hindi.
- The size of the letters and numerals to be used on the label in proportion to the size of the principal display panel is specified.
- Food claimed to be enriched with the nutrients like minerals, proteins, vitamins should give the quantities of such additions.
- All food articles for which standards are not specified in this Rule can be sold as proprietary foods.
- Packages, labels and advertisements of Edible oils and fats should not use any exaggerated expressions like "Super Refined", "Extra Refined", "Micro Refined", "Double Refined", Anti Cholesterol, Cholesterol Fighter, Saturated Fat Free etc.
- All retail food packages should carry a declaration on the label of the package indicating the month and year in capital letters up to which the product is the best for consumption.
- Two optional formats are specified for printing this information.
- For packages of all types of milk, bread, Indian ethnic snacks which have short shelf life like dhokla, bhelpuri, khoa, paneer etc., pizza, doughnuts, and uncanned packages of fruits, vegetables, meat, fish it is mandatory to print the 'best before date', along with month and year.
- Only few specific food items are allowed to be irradiated like onions, spices, potatoes, rice, semolina (sooji or rawa), wheat flour, mango, raisins, figs, dried dates, ginger, garlic, shallots (small onions), meat and meat products, including chicken, fresh sea foods, frozen sea foods dried sea foods and pulses and the doses of irradiation are also specified. All irradiated foods are required to be labeled properly with the symbol of irradiation.

B. Specific Requirements

Use of Color

Any food item using extraneous coloring matter whether natural or synthetic should declare on the label "CONTAINS PERMITTED NATURAL/ AND SYNTHETIC COLORS". Very few coloring materials are allowed and that, too, in limited items.

Use of Flavor

When an extraneous flavoring agent (only those allowed under Rule 63) is added in any food product it has to be declared on the label as "CONTAINS ADDED FLAVOR".

Use of MSG

Every advertisement and packages containing added MSG, shall carry a declaration on "not recommended for infants below 12 months" in the prescribed format.

Admixtures or Additions

All food items containing any addition or admixture or deficiency, their labels or price lists or their advertisements should clearly be declared on the label along with the nature and quantity of such addition, admixture or deficiency.

Additional Label Requirements for Various Specific Food Articles have been mentioned in this Rule.

A few additional label requirements have been mentioned in the PFA Rule for specific food articles.

Infant Milk Substitute and Infant Foods

- Mandatory labeling, like the declaration, "Mother's milk is best", "to be sold only under the advice of a health worker" etc.
- The containers of infant milk substitute meant for low birth weight infant (less than 2500 gm) or labels affixed thereto shall indicate the following additional information:

  1. "For low birth weight (less than 2.5 kg)" in capital letters along with the product name in central panel.
  2. "To be taken under medical advice" in capital letters along with the product name in central panel.
  3. "The Low Birth Weight Infant Milk Substitute shall be withdrawn under medical advice as soon as the mother's milk is sufficiently available".
  4. The products, which contain neither milk nor any milk derivatives, shall be labeled "Contains No Milk or Milk Product" in conspicuous manner.
  5. The container of infant milk substitute for lactose-intolerant infants or label affixed thereto shall indicate conspicuously "Lactose Free" in capital letters and statement "To be taken under medical advice".

Natural Mineral Water

It is mandatory for the manufacturers to print "Natural Mineral Water" on the packages of the bottles of water sourced from natural or drilled sources and bottled without any treatment other than filtration, under the certification of Bureau of Indian Standards.

Packaged Drinking Water

Packaged drinking water is also required to print "Packaged Drinking Water" on the packages of the bottles of all other drinking water packages other than Natural Mineral Water, under the certification of Bureau of Indian Standards.

Fruit Syrup, Fruit Juice, Fruit Squash, Fruit Beverage, Cordial or Crush

- Restriction on use of these names on synthetic products. All the products should contain the prescribed amount of fruit juice.
- Synthetic products, which do not contain fruit juice, should not use as any of the above names. Every package should be clearly and conspicuously marked as "synthetic product".
- Fruit squash containing additional sodium/potassium salt should be specifically declared.

Coffee, Coffee Chicory milk

Every package containing a mix of coffee and chicory should have a label declaration on the percentage of each in the final product in the prescribed format.

Condensed/Dried milk

Every package of condensed/desiccated (dried) milk should declare the equivalent quantity of liquid milk that the contents of the tin would produce.

Flavored Tea

Only those manufacturers who are registered with Tea Board shall sell flavored tea. Flavors of non-vegetarian source cannot be used.

Dry Fruits and Nuts

Dry Fruits and nuts should not contain more than 5% of insect damaged fruits or nuts by count.

Honey

The word honey or any words, marks, illustrations or devices that suggest honey should not be used on the label or package or advertisement of any food that resembles honey but does not contain real honey.

Products containing artificial Sweeteners

All packages and advertisements of foods containing artificial sweeteners should declare the name of the artificial sweetener and also "Not Recommended for Children".

Packages and advertisements of Aspartame and products containing Aspartame should also declare "Not for Phenylketoneurics".

The Problems

The world over, there is a change in perceptions about the methods appropriate for ensuring healthy

food for all. The focus of the PFA Act, however, continues to be on the detection of adulteration and prosecution. It's a statute relying heavily and almost exclusively on penal provisions. Though the importance of shifting emphasis on "good manufacturing practices" is being realized, keeping in view the huge number in the small and cottage sector operations, it becomes difficult to leave the basic of safety only to GMP.

The most difficult clause in the PFA, which puts industry in a difficult situation, is the fact that this Act does not differentiate between minor variations from adulteration. The Act specified that any article of food which does not conform to the standards specified in Appendix B of the Act will be treated as adulterated because the quality or purity of the article falls below the prescribed limits. Even when there is marginal deviation from the prescribed standard, the article of food is considered adulterated.

There is no term as "Substandard" or "Misbranding" in the Act. The degree of punishment is equally severe for all types of violations. In any system, however, small deviations cannot be ruled out because of weather conditions, which affect the quality of raw materials, machine errors, etc. Such deviations within certain tolerance limits cannot be considered as adulteration, provided that they are injurious to health. It has been a long standing demand from the industry that for minor omissions or variations, which do not have any bearing on the quality or safety of the product, should be treated differently and the degree of punishment should be proportionate to the gravity of the offense.

The Act does not just specify general standards for each type of product, rather, it lays down individual standards for most of the common food products being manufactured in India going into minute details which results in almost specifying the recipe of the product. Use of additives is strictly restricted to very few specific products. For example use of artificial sweeteners is not allowed in any product other than aerated beverages, hence low calorie or dietary food products cannot be manufactured in India.

This strict restriction on the use of ingredients and additives at times holds back industry from new innovations. However, the Indian pattern is somewhat desirable from the view that Government has very limited resources in both training of personnel as well as well equipped testing laboratories. Flexible allowances on the use of additives and other ingredients in new innovative products may pose a problem of available testing and analyzing methods and equipment.

Getting changes to standards approved requires specific application from the concerned industry or company and has to go through the whole process of approval first by the respective subcommittee and then subject to its approval, clearance from the CCFS, which is quite time consuming.

Compliance with WTO and its SPS Agreement

India is an active member of WTO and is a signatory to all the major Agreements. Though the Indian economy in the recent past has brought in policies which are more outward looking, the food control system has not quite kept pace with these changes. The Sanitary and Phytosanitary (SPS) agreements and the World Trade Organisation have indicated the path to follow to achieve ready acceptance in world markets. The SPS agreements calls upon members to harmonize their sanitary and phytosanitary measures with international food standards, food additive, ADIs, pesticide and animal drug residues, contaminant tolerances, methods of analysis and sampling and codes and guidelines for hygienic practices.

However, recently the Department of PFA in the Ministry of Health has taken up this issue quite seriously and a series of activities have been initiated to harmonize the laws with the Codex guidelines as required by WTO. The labeling requirements are being considered first and a lot of discussions and debates have already been undertaken to incorporate certain amendments. As far as standards are concerned, they are quite transparent and simple. Apart from the restrictive approach towards additives and ingredients, there are not many others, which could hamper the import of products into India. These issues are also currently under discussion and amendments are being attempted.

Actions have also been initiated in the fields of pesticide and animal drug residues, contaminant tolerances and guidelines for hygienic practices to facilitate exports, but in a country of this size and number it is not an easy task. India is a member in all Codex Committees and regularly attends and participates in the meetings of Codex. For all the Codex Committees, the Indian Government has constituted respective Shadow Committees and all the issues are discussed and debated at length and India's point of view presented at the Codex meetings. Accordingly, changes are being considered for the domestic market.

This paper has been excerpted from "Food Standards and Labeling Systems in Asia and the Pacific" by APO, Tokyo (2002). □

Feature

Changing Trends of Technological Research in Post-Globalization India

Binay Kumar Pattnaik

Changes unleashed by liberalization and globalization acquire great significance in the context of India, as its economy had been inward looking for decades. This paper brings out the unfolding technological dynamism experienced by a developing economy after being integrated to industrial capitalism through globalization.

Binay Kumar Pattnaik is a faculty member at the Indian Institute of Technology, Kanpur.

Globalization has unleashed changes of unprecedented magnitude in various aspects of the economy, particularly in the industry and trade of developing countries. Owing to globalization, the Indian economy has moved from the structuralist to the neo-liberal type and from inward-looking (import substituted) to outward looking (export-orientated) type. The impact of globalization acquires significance in the Indian context particularly in the light of its socialistic closed door policies pursued for decades.

Aspects of technological development trends in India are put forward under a three-fold classification (1) trends of change in the industrial research laboratories (particularly in the public funded ones), (2) trends of change in technological research in academics and (3) trends of change in R&D and technology transfer in the manufacturing sector (not the service sector). Globalization of a technological regime entails; (i) global R&D management practices through overseas subsidiaries, (ii) global sourcing (of knowledge, skills and manpower) for R&D through alliances, joint ventures with foreign firms or research institutes abroad, (iii) global exports/licensing of technologies abroad, (iv) global exploitation of local knowledge bases for processes and products and (v) to be part of the global IPR system trade regime.

Technology in Industrial Research Laboratories

With the opening of the once-protected market of India, enormous volume of foreign technologies have entered the Indian market, particularly in the consumer goods, heavy industries, and in high-tech areas of electronics and telecommunication sectors. Not that in these areas the indigenous technology was playing any significant role, but by the opening of the flood gates the indigenous technological capabilities in these areas got pushed to the brink and prospects for further growth appeared to be doomed. That apart, becoming a sig-

natory to GATT in the mid-nineties has jeopardized the indigenous R&D/technological capabilities in India, although it has also subsequently created significant opportunities because the so-called indigenous capabilities did not remain strictly indigenous and fast acquired inputs from abroad. In the Indian industry, because of the collaboration benefits accrued from foreign collaborations, the new drive became the MNC-led growth. In case of the public funded R&D institutions it was not very different for these could also sacrifice their indigenous character and acquire inputs from abroad for their own projects and even launch joint ventures with foreign participation (both for process and products).

Immediately after the liberalization of policies in the early 1990s, the funds for CSIR (Council of Scientific and Industrial Research) laboratories were also frozen like for the IITs. The CSIR laboratories were asked by the Government of India to generate funds for themselves. It was proposed that government support of CSIR be reduced to the ratio of 40:60 (i.e., government: self). Followed by this was the revamping of the organizational structure of the laboratories and a change in their philosophy and outlook. Since then the R & D programmes at CSIR laboratories have been reoriented. The CSIR claimed in the late-1990s that it generated around 26% of its own revenue, which is far below its expected limit of 60%. (A measure of success in their market orientation could be the phenomenal rise in the value of their contracted R&D and technical services (Gupta, et al, 2000) which has grown more than two times from Rs. 800 million in 1992-93 to Rs.1900 million in 1996-97.)

As a reflection of their changed outlook, the laboratories now emphasize the commercialization of their processes/outputs. The policy protection umbrella earlier given by the government has been taken away, and no more preferential treatment is being given to CSIR technologies. Laboratories of CSIR have to compete in the open market with foreign technologies for their marketing. It is no longer mere sales. It is now marketing by identification of potential licensees or clients. The laboratories are now learning to package their own services, technologies/know-hows. Hence laboratories are seriously canvassing for their post transfer services. No longer will these laboratories exclusively rely on DSIR (Department of Scientific and Industrial Research) or NRDC (National Research Development Council) for marketing their products. Most of them have developed their fulltime units for Marketing and Business Development. And CSIR now claims to have brought about a fundamental transformation in the mindset of many of its scientists as they are now appreciative of the roles others play in the innovation chain and are conscious of client needs of quality and confidentiality, too, notes Joshi (1995). These are great points of departure compared to pre-liberalized mindsets of scientists.

Many of these labs, like NCL, have emphasized new areas of attention that are considered to be potential for successful commercialization. These areas are nothing but stages between invention and implementation, which were not emphasized earlier. For successful transition the inventions now pass through several steps like (1) revalidation (reproducibility) in the hands of workers elsewhere, (2) trial of up-scaled versions to find out performance of various stages and bottlenecks involved there in and (3) techno-economic feasibility data are then put together for making full-scale calculations, to ensure economy of scale production, (Joshi A P; 1995).

CSIR laboratories now often offer performance guarantees to their technologies. Besides, laboratories have made strategic alliances with NSIC (National Small-scale Industries Corporation) and APCTT (Asia and Pacific Centre for Technology Transfer), to offer combined and complementary services on providing information pertaining to technology source, technology evaluation and assessment, equipment leasing, financing, marketing, etc. Laboratories have selectively allowed foreign participation in their own projects and also have participated in overseas projects of firms and laboratories abroad. This enhances their revenue earning capabilities and technological abilities.

If the reorientation is measured in terms of the success in commercialization of their services and technologies, Gupta, et al (2000) found that the CSIR labs have achieved reasonable success in marketing their services/technologies to industry. Since the labs' attempt to successfully reorient themselves to the market is to a great extent dependent upon their interactions with the industry in many areas (like, undertaking industry sponsored R&D projects, providing consultancy to industry, licensing out technology to industry, training industrial personnel, sharing research findings with industry, jointly working on projects with industries, making lab facilities available to industry, involving industry in seminars/workshops, and visiting each others' labs), all the labs have mobilized their actions to widen and deepen their interactions with the industry, but still a great deal of work lies ahead in this regard. Obviously the "successful labs" are found to be doing much better at interacting with industry than the "not so successful" labs. Similarly the "successful" labs have made conscious efforts to identify and then remove the barriers of interaction with industry.

The biggest perceived barriers have been the absence of office and funds to promote industry and lab interaction and the absence of awareness among the

industries about the capabilities of the labs. Efforts are on among labs for such promotional activities which are in fact moving in the right direction. Further, there is wide spread perception among the lab scientists that to make market orientation more successful there is a strong need to introduce market-focused performance measures in the evaluation system (of labs and scientists) in order to make it more objective instead of leaving it subjective and vague. It will certainly encourage scientists also to direct their efforts in the desired direction.

The other new strategy of CSIR labs is to earn revenues through patenting, consistent with the perception that patents are now global sources of revenue. Patents of processes and products, even if not commercialized, can fetch revenues. The Director General has been emphatic about developing a patenting culture in CSIR and it is reflected in the substantial rise in its number of patents filed and granted in the USA and Europe (almost 200%) in the later 1990s (Bowonder and Richardson; 2000).

The emerging challenges for CSIR scientists:

- Developing and cultivating a patenting culture and patenting skills in India,
- Patenting micro-organisms, plant varieties, and materials/substances that have commercial implications,
- Assisting the Indian industry to enhance its level of productivity, quality, efficiency, and technology modernization,
- Developing fully-baked and user-targeted technologies for the rural contexts (recently it was reported by Pulamte and Abrol, 2003 that CSIR's rural technologies lack user connectivity for the said reasons).

However the experience of private laboratories during this period of liberalization has been a matter of no less enthusiasm because their rising technological efforts particularly, those in drugs, pharmaceutical and allied areas, have yielded fruits. Many domestic laboratories/firms are focused on rediscovering more efficient and cheaper methods of production and concentrated on producing clones and generics of products invented by global giants (Mehta and Sarma; 2001). Re-engineering and reverse engineering of processes and products became a way of life for some domestic laboratories/firms. A few of them like, Ranbaxy Laboratory, Dr Reddy's Laboratory, Lupin Laboratories, Sun Pharma, Dabur, etc have very successfully developed new products with a potential for international markets and have entered into agreements with MNCs (multi-national companies) for marketing those processes.

Technological Research in Indian Academics

After the liberalization of policies and globalization of the economy, scientific and technological research in Indian academics had been threatened. Because of the shifting emphasis of the Indian Government in the early-1990s to primary education, higher education and academic research in India were somewhat left behind. This happened in the first half of the 1990s under the Congress Government.

As the reflection of the shifting policies in the early years of the last decade (i.e, 1990s), budgets for premier institutions of technology like the Indian Institutes of Technology (IITs) and the Indian Institute of Science (IISci) Bangalore, were frozen and these institutions were asked to generate the remaining parts of their budgets for themselves. The first victims of this measure were the libraries of IITs. And the then infamous devaluation of Indian rupee twice took a heavy toll on scientific journals from libraries which are mostly obtained from the west and are paid for in hard currencies of the western countries. It was the time when the frontline scientific and. technology journals also had hiked their subscriptions rates because of the growing cost of the R & D in the west. More than 40% of the costly and highly prestigious journals were discontinued in a phased manner from the libraries of IITs. Major libraries were asked to share resources on a mutual basis. This affected academic research adversely. Even laboratories in these institutions experienced obsolescence in key areas of equipment/instrumentation that were usually imported.

Another notable development on the academics of technology in the early 1990s was even more serious a concern. Because of the government's budget cut for the IITs, faculty members were required to generate funds for the Institute through R & D works. So small research projects, irrespective of their academic value, were discouraged on IIT campuses as if research projects were big sources of earnings. In fact, in spite of IIT being teaching institutions, these were treated like full-time R & D institutions. This was very much like aping the policies of the western industrialized countries (having an R & D culture), as those countries on an average in the 1990s spent nearly 3% of their GNPs on the R & D (DST, 2002) and related activities and industries spend 3 to 4% of their earnings in R & D. Under these conditions alone the R & D institutions can fund themselves. On the contrary in India, the total investment in R & D was less than 1% of

the GNP, the bulk of which (80%) is made by the Union Government and not by the industries. IITs were wrongly placed and wrongly treated as fulltime R&D institutions of the west. The campuses were whipped to generate a sizeable part of their revenues from industrial R&D activities when these are not located in and around industrial belts and the Indian industries have a poor R & D culture. And it was spelled out by the MHRD (Ministry of Human Resources Development) of the Government of India then that (apart from the basic grant from the government which was frozen) the additional revenue generated by the Institute would fetch a matching grant from the government.

Under pressure to generate funds and to survive, the IITs launched their own all out efforts. A special post of Dean, Resource Planning and Generation was created in all the IITs. The other way to generate resources for IITs was to run short-term courses. Thus, in these premier institutes of technology, quality research suffered temporarily.

The dearth of funds created new standards for academicians; that is, the thrust was now on how much money one could generate indirectly for the institute (through research/ consultancy projects and short term courses) in place of how many good papers/patents one could produce. It even became strong criteria for career promotions for faculty members at IITs. But this trend did not last long. Because by the mid-1990s, IIT campuses had already rediscovered their alumni and impressed upon them the idea of forming alumni associations, both in India and abroad to make financial contributions and had got the approval from the government to receive funds from abroad as it was not legally permissible then under FERA.

The ex-IITians responded quickly, the idea of "paying back to the country" gained currency among ex-IITians as paying back to the Alma-mater had already become a culture in the United States. The Alumni Associations of IITs donated substantially. IITs experienced a sigh of relief. By the end of the decade almost all the campuses had formed their Foundations in US where the ex-IITians are mostly concentrated. The word had spread among the high-tech circles of ex-IITians abroad that IITs are not being supported by the government of India any more. They were informed that their premier Institutes of technology in India are under serious financial stress. Some of the more illustrious alumni, particularly those at the top of software business, like Kanwal Rekhi, N.R. Narayan Murthy and a few others even sent a proposal to the Union Government in late-1990s to take over the IITs if the MHRD is not in a position to fund them. The Prime Minister's Office asked the five-member team of Rekhi to formulate an alternative body to IIT council (the apex body that governs the six IITs) and work out the details of the norms of transfer. It was leaked to the press, the press raised an outcry and the move to privatize IITs was stalled. It was feared that after this take-over IITs would not remain as IITs, but that rather these would be reduced to service stations of these high-tech giants. The takeover move might have been stalled but the financial contribution of these high-tech giants to IITs continued and has become a noteworthy phenomenon in present times.

Meanwhile, with an improved financial situation, government contributions to IITs also increased in the late-nineties and the campuses experienced academic (new departments and research programmes) and infrastructural expansions (acquisition of journals/books to libraries, upgrading obsolete lab facilities, buildings to house new programmes, etc). But the MHRD took note of the flow of funds to IITs and their subsequent academic and infrastructural expansions. Maybe the flow of funds from the alumni associations had become an eye sore as the MHRD recently had floated the idea of routing these funds through its newly founded Bharat Shiksha Kosh.

It would not be out of context to mention a few lines about the pattern of changes experienced in the placement of IIT graduates. IITs had been known for decades for the migration of its graduates. There may not be any change in this phenomenon after liberalization/ globalization of the economy. The better graduates of IITs do go abroad even today for higher studies. But the pattern of campus recruitments has changed over this decade. Because of the boom of the software industry, mostly IIT graduates, not necessarily only those of the departments of computer science and engineering (but of all departments), opted for software jobs because they are white collared and highly paying. In view of these many conventional engineering companies (except TELCO, TISCO, L&T and the like) have stopped visiting campus recruitment cells of IITs. But because of the temporary recession in the IT sector, a section of IIT students is now opting for domestic employment in their conventional engineering disciplines. However, a mark of distinction of the last decade in terms of placements owing to globalization of the economy has been the growing employment opportunities abroad (mostly because of "Body Shopping") for Indian graduate engineers (not necessarily IIT graduates). Because of the boost in IT and software business in the west, plenty of graduate engineers working as IT personnel have found foreign placements and have earned hard currencies. These jobs have all been contractual and part of the larger projects of international subcontracting by IT/software giants like IBM, Microsoft, Linux etc (but these might not be the hardcore R & D jobs).

The other noteworthy development in technology education in India necessitated by globalization has been the establishment of IIITs (Indian Institutes of Information Technology) by MHRD at the end of the 1990s to help produce 600,000 software/IT professionals in India every year. These institutions are now facing difficulties in attracting the brighter students because of the recession in the IT industry. And during this period also India witnessed mushrooming growth of IT education centres spread over small towns that are privately run, notably NIIT, APTECH, etc which are franchise based.

R & D in Indian Industry

Foreign Collaborations and Technological changes

The other major change that is visible after liberalization is the changing nature of foreign collaboration. Maybe the foreign direct investments (FDIs) did not come into expected sectors such as infrastructure and heavy industries, but these have come in the already existing sectors. It came significantly in the consumer goods sector. In case of fresh FDIs where capital came from foreign firms, these almost all the time are accompanied by technology. This gave rise to a visible new trend of collaborations called the JVC (Joint Venture Collaborations) firms. By JVC firms I meant the ones that have almost a 50% tie up with a foreign partner. In such cases the Indian partners feel very comfortable about it, as they play the role of an equal partner. In these JVCs the conditions of the collaborations/memorandum of understanding (MOU) are not too burdensome for Indian partners. These, after all, feel contented that even if their technology is not the state of the art, they get fairly developed technology from the partner to produce better quality goods for Indian markets, and even at times they get the collaborators' trade marks to get leverage in marketing.

But as Nagesh Kumar (1994) pointed out and Kher (2001) corroborated, the JVCs of this type do not necessarily involve transfer of technology. Developed technology is not acquired but semi-finished products are brought to India to be assembled and sold under a foreign brand name in India. This does not involve dissemination of knowledge and growth of technological capabilities of Indian firms. Kher (2001) also notes that in spite of being equal partners, the foreign firms do not pass on sufficient technological knowledge to the Indian firms.

Among joint companies with foreign majority equity as well as foreign MNCs with their wholly owned subsidiaries, neither have the necessity of conducting high-end R & D nor have the necessity of formally transferring technology from the United States, the European Union or Japan. These heavily-endowed FDI firms compete with each other for somewhat obsolete technologies in the Indian market because foreign firms do not introduce their state of the art process and production technologies to third world countries.

Heavily-endowed FDI firms in India have experienced better growth in the post-liberalization era because of intra-firm technology transfer. Narayanan (2004) drives home this point in his recently reported study among Indian automobile firms. In his econometric analysis, Narayanan shows that during the early years of post-liberalization, i.e, 1991-92 to 1995-96, the growth rate among the automobile firms in India was determined by variables capturing technology paradigm and technology trajectory shifts, which was possible only among MNC affiliate firms. He further adds that, because of the resource advantage enjoyed by these (FDI) firms, even in the era of strict control and regulations when government policy itself was imposing limits of growth, these firms tended to record higher growth rates over the domestic firms. But under a deregulated policy regime, imports of capital goods (not others) were the only technology variable which enabled the automobile firms to achieve higher growth rates. When it comes to other modes of technology acquisition, i.e, through direct purchase (by lump sum and royalty payments), through in-house R&D along with interaction between the two, which is mostly practiced by domestic firms, it appears that these firms are caught in a dilemma. Expenses incurred on these activities may not necessarily give them any advantage to secure growth, while not spending on these activities may also harm them and make them feel left behind. On the contrary in a deregulated economy it is the MNC-affiliated firms with high foreign equity participations that have experienced considerable intra-firm technology transfer as well as access to the brand name of the parent MNC to face the market onslaught.

Heavily-endowed FDI firms in India have experienced better growth in the post-liberalization era because of intra-firm technology transfer.

In the case of firms with FDI in the form of minority-equity participation the earlier type of exploitative relationships persist as the MNCs continue imposing several of those prohibitive and tied purchase conditions on Indian partners (Kher; 2001). In order to face the threats of the first two types of FDIs (i.e. 50/50 and majority equity participation), certain Indian firms have merged together as a survival tech-

nique to be stronger and oppose MNCs in the Indian market.

The other visible change after liberalization is a changing nature of foreign technical collaborations (not financial) by Indian firms, such as Compton Greaves, L & T, etc. Even very large PSUs like BHEL (Bharat Heavy Electricals Ltd), BEL (Bharat Electronics Ltd), ITI (Indian Telephone Industries) Ltd etc fall under this category. These firms now often opt for pure technical collaborations without financial participation from abroad. Because of their experience and bargaining power, the depth of technology transferred to them is sufficiently high so that these firms do not fall back upon the foreign supplier firm for further assistance on the same know-how. In many cases, it is observed that these Indian firms buy only the designs and not other accessories. This is some kind of an achievement for Indian firms to acquire unpackaged technologies from foreign firms. Because in the process of acquiring packaged technologies from abroad Indian firms earlier used to acquire many irrelevant technological components and consequently ended up paying more foreign exchange. Buying unpackaged technology also implies that the Indian firms have acquired sufficient knowledge on the said technologies before acquisition, by doing preparatory research.

The access of large Indian firms to international technology shelves has grown many-fold. These firms are now better informed about the sources of technology because of their vast past experiences. They even regularly opt for new foreign collaborators instead of repeatedly obtaining the developed version of the obsolete technologies from the same foreign firms. They now buy unpackaged technologies. This could be possible because of certain changes in the international technology market where now some of the international technology sellers are not the typical MNC-type firms but, are technology-intensive small firms that are new players in the international market and do not behave like typical MNCs. Even some of these Indian firms now look for horizontal transfer of technologies and are intending to create their own sub-licensees in India and may be in other developing countries. The last notable observation is about the medium-size Indian firms that have opted for foreign collaborations, which are often repetitive in nature, and have experienced qualitative change in their relationship with their foreign collaborators. They now tend to develop longer and lasting relationships with their foreign collaborators so that business interests are protected and smooth transfer of technology and technical assistance takes place. This observation is also based on fieldwork done in the mid-nineties concerning foreign technical collaborations

A related visible change in FDI/JVC firms pertains to dispute settlements with foreign collaborators. Earlier, Indian firms had to fight the legal battle on the collaborators' home turf. After India passed the Arbitration and Conciliations Act of 1996 the dispute settlements among collaborators in India has acquired international legal sanctity as this has been made in consonance with the UN Commission on International Trade Law (1985). In view of this development and earlier bad experiences of loosing legal battles to foreign collaborators, Indian firms now have started involving legal experts and R & D experts in the MOU negotiation meetings and agreement signing.

Of course, in the context of FDI/JVC in India after liberalization, worth mentioning is the arrival of MNCs to set up their R&D centres in India. Since India signed the GATT in 1993, more than 60 global firms have set up their R&D centres in technology intensive sectors for using skilled Indian manpower. Prior to 1991 there were only two such centres. MNCs have internationalized their R&D activities and of late have set up their R&D centres in a developing country like India. These centres are either global/regional centres of MNC-R&D or are technological alliances/JVC R&D projects in India. MNC-R&D centres are all in high tech areas of electronics, biotechnology, pharmaceuticals and chemical technologies. Examples of the first type (FDI as global/regional R&D centres) include, the Astra-AB Research Centre India (Bangalore), Texas Instruments India (Bangalore), Asia Pacific Design Centre of SGS-Thompson, Motorola VLSI design Centre (Hyderabad), GE Research Centre India (Bangalore) and Daimler-Benz Research Centre India (Bangalore). Examples of the second type (Technological alliances/JVC R&D centres) are, AVL Austria with Mahindra and Mahindra, Affymax with Glaxo India, Wockhardt with Sidemark Labs, Novo Nordisk with Dr Reddy's lab, Cheminer Drugs Ltd with PRI Inc, Airbus with Hindustan Aeronautics, IDEA with TELCO, Mallinkrodt with NATCO Pharma, Eli Lilly US and Pfizer with Ranbaxy India Labs, Du Pont US, Abbot Labs US, Park Davis US, Smith Kelin and Beecham US all with IICT (Indian Institute of Chemical Technology) Hyderabad and Du Pont US, Akzo Netherlands, GE US, all with NCL (National Chemical Laboratory) Pune, Cadence, IBM with Indian Institutes of Technology Kanpur and Delhi respectively, Nokia, Nortel, L G Electronics and Rational Software with Indian Institute of Science Bangalore and Mobil with Indian Institute of Petroleum.

Some of these strategic alliances of R&D between firms are made for purposes like overseas licensing, global marketing and joint product development.

tices in Indian Metal Industry" reports the kind of changes the R&D units in metal industry have experienced during the last couple of years. Having experienced even closure of the R&D units, these industries have developed certain adaptational tactics in R&D management practices to face the onslaught of competition. To sum up a few of those:

(i) Integrating R&D to the strategic business management to achieve business goals: shifting R&D activities from product refinement to product development,

(ii) Restructuring R&D units: delayering of the R&D organizational structure,

(iii) Implementing quality (improvement) systems,

(iv) Increasing interaction between R&D and shop floor by establishing Technology Dissemination Centres and the like,

(v) Increasing emphasis on cross-functional teamwork as opposed to being "technology driven" or "production driven".

However, this post-liberalization healthy trend is not confined to the Indian metallurgical industry alone. There is similar evidence from large firms, particularly in sectors like the pharmaceutical, electronics and automobile. Lall (1995) (as cited in Bowonder and Richardson, 2000) has taken note of recent developments made by some of the in-house units in the Indian manufacturing sector. Lall, with the help of a few successful case studies, has articulated various types of in-house technological development, such as: (i) innovative process technologies (e.g, new molecular product developed by Dr Reddy's Laboratory), (ii) absorption of acquired technology and its further upgradation by progressively moving into new and complex activities for value-added products (e.g, Titan Industries Ltd.), (iii) assimilation of acquired technology to increasing local inputs/designs and linkages (e.g, TELCO's new car Indica V2) and (iv) achieving competence in complex technologies in local use (e.g, L & T and Engineers India Ltd together developed fluidized catalytic converter for Reliance Industries).

Based on the case studies reported by Lall and their own case studies taken from Indian manufacturing sector, Bowonder and Richardson (2000) have articulated the emergence of five categories of in-house technological developments causing technological deepening in Indian industry in the post-liberalization era. These global competitive technologies causing exports are, (i) supplier dominated technology, (ii) scale-intensive technology, (iii) specialized supplier of technology-based equipments, (iv) science-based technology and (iv) information-intensive technologies. The authors generalized that although there have not been substantial increases in the number of innovations, there has been acquisition of technological mastery by these Indian firms. Some of these have been achieved by using and absorbing technology efficiently while others have been rapid in learning and adapting to local factor endowments. The authors have pointed out the upward movement of these manufacturing industries in terms of long term technological accumulations through in-house efforts. These developments noted by Lall as well as Bowonder and Richardson are based on highly selected case studies confined to very large size firms with basic technology acquired from abroad.

In a recent study carried out in the Indian Chemical sector by Hirwani (2004), a CSIR scientist, shows healthy trends of in-house R&D activities in recent years that are in agreement with our earlier reported trend developments. In a sample of MNC-affiliate (FDI) firms having recognized R&D units, he found that only 5% of the units still function purely as support labs while a good majority of the units, i.e. 70% have moved along the value chain to indulge in R&D activities that enable the company to upgrade the technology, implement cost effective processes, introduce new products for local market and enhance the competitiveness of the product in global market. And 25% of the units are found to have made progress in exploiting domestic capabilities in the global market. On the contrary, in the case of the sample domestic firms with recognized in-house units, 10% of the R&D units are found to be still functioning as support labs while the vast majority of the units, i.e. 80% are now indulging in R&D activities that enable the firms to upgrade the technology, implement cost-effective processes, introduce new products for local market and increase export competitiveness. And only 10% of these R&D units are found to have made progress in exploiting domestic capabilities for the global market.

Hirwani (2004) observes that in the chemical sector it is only the selected large pharmaceutical firms that had invested in in-house capability building and maintained the skills at the cutting-edge. These firms in particular are mostly engaged in process research rather than product research and are moving up on the R&D value chain. The research for discovery of new molecules requires synthetic chemistry skills that have been built in the industry over that last 50 years. The Indian pharmaceutical sector has developed core competencies in the synthesis of organic molecules of considerable complexity. Today, this competency is being leveraged to be the most low-cost producer of bulk drugs and other specialty chemicals. This is a case of competency-based competition in which Indian firms are enjoying the limited fruits of their capabilities in the fiercely competitive global market. In

view of these developments, the Indian pharmaceutical industry today is repositioning itself to be part of the global R&D platform.

Lastly, although venture capital started in 1986 in India, it could not catch up, but the post-liberalization technology-based venture that started in 1996 under the Technology Development Board has been a major success in India. Under this scheme, technology development projects are funded on a 33:33:33 percentage basis by the Board, Banks and Entrepreneurs. A large number of heavily funded projects are launched, amidst the newly found technology entrepreneurship atmosphere for technological innovations in pharmaceuticals, machineries, new materials and various aspects of biotechnology. And the success cases have not been uncommon.

Conclusion

The threat perceptions made in the early years of liberalization by the Indian research scientists in CSIR labs, in premier academic institutes like IITs and those in industrial R&D units, turned out to be short lived and premature. As the dynamics of globalization unfolds itself gradually, its benefits have been appropriated by these research organizations by means of unleashing the spirit of competition and market orientation within.

Particularly in the Indian industry, after almost a decade and a half now it is observed that the industrial technological regime has slowly undergone qualitative changes to acquire technological mastery, to be competitive and outward looking (no longer for mere import substitution) in several sectors. Indian enterprises have learnt to survive and become competitive in this troubled water of globalized economy by making fences with powerful market forces called the MNCs. Globalization has strengthened manifold the Indian technological capabilities in industries because of its impact (although selectively) realized in terms of; (i) Learning competitive practices, (ii) Learning through experiences (learning from failures as well as learning by doing) and (iii) Learning from collaborations and strategic alliances (developing cognitive skills to be innovative) and (iv) Learning to pursue "business driven" R&D.

References

Bowonder, B and Richardson, P.K. (2000). "Liberalization and the Growth of Business-Led R&D: the case of India". R&D Management. 30 (4). pp. 279-288.

Department of Science and Technology, (1999). Research and Development Statistics 1996-97. New Delhi: Government of India, DST.

Department of Science and Technology, (2002). S & T Year Book, R&D Expenditures as Percentage of GNP for selected Countries (Fig.43), Government of India, DST Publications, www.nstmis.dst.org/

Gupta, Ashok. K. Bhojwani, H.R. Koshal, Rajinder and Koshal, Manjulika. (2000). "Managing the process of market orientation by public funded laboratories: the case of CSIR, India". R&D Management. 30 (4). pp 289-296.

Hirwani, R.R. (2004). "Globalization of R&D and its impact on industrial R&D in India". Work in Progress (doctoral thesis) Paper, presented in the workshop on Science Technology and Society Studies organized by JNU in association with NISTADS, New Delhi during 25-27 March 2004.

Joshi, A. P. (1995). "Technology Transfer- New Strategies". in S C Pakrashi and G P Phondke (eds) Science, Technology and Industrial Development in India. PID of CSIR and Wiley Eastern Ltd, pp.101-105.

Joshi, S. K. (1995). "Impact of Liberalization on CSIR". in S C Pakrashi and G P Phondke (eds) Science, Technology and Industrial Development in India. PID of CSIR and Wiley Eastern Ltd, pp.21-29.

Kher, Manik. (2001). "Technology Assimilation in Joint Ventures, the Indo – MNC Experience". Response Books, pp.58-70 and 92-97.

Kumar Nagesh. (1994). "Multinational Enterprises and Industrial Organisations, The Case of India". Sage India, pp.159-173.

--------.(2002). "Globalization and the Quality of Foreign Direct Investment". India: Oxford University Press, pp.144-147.

Mehta, P. K. and Sarma, A. (2001). "India: Coping with the Challenges of the Global Technology Order", Science Technology and Society, An International journal Devoted to the Developing World. Vol 6, No.1, January-June.pp.23-60.

Narayan, K. (2004). "Technology Acquisition and Growth of Firms: Indian Automobile Sector under Changing Policy Regimes". Economic and Political Weekly. Vol XXXIX. No.5. Jan 31. pp. 461-471.

Pattnaik, Binay K. (2006). (Forthcoming) "Determinants of Technological Innovativeness Through In-House R&D: A Case Study of Indian Electronics Industry". in B K Pattnaik (edited), Industrial R&D in India Under Globalisation. New Delhi: The New Age International.

----------. (1999). "Role of Technology Import Policies in Indian Private Sector: Retrospects and Prospects". in Binay K Pattnaik (edited), Technology Transfer and In-house R&D in Industry, Vol 1. New Delhi: Allied Publishers, pp.92-97.

Pulamte, L and Abrol, D. (2003). "Technology Transfer for Rural Development: Managing R&D at CSIR". Economic and Political Weekly. August 2, pp.3315-3318

Ramachandran, R. (1998). "Funding Technology Development". Business India. August 24- September 6. pp. 125-130.

Researve Bank of India. (2002). Handbook of Statistics on Indian Economy.

Suman, Shikha.(2003). Managing In-house R&D: An Exploratory Study of Indian Metal Industry. Unpublished Ph.D thesis. India: IIT Kanpur. pp. 161-168.

□

Feature

Diagnosis and Initiatives for Improving Competitiveness: A Case of SME

Rajesh K. Singh, Suresh K. Garg & S.G. Deshmukh

This paper endeavours to analyse market conditions for SMEs as well as initiatives needed by them to become competitive in the globalized economy. It is illustrated with the help of a case study. On the basis of various inputs, this organization's initiatives for product design and development, six sigma projects, TPM and for defining key indicators of performance measurement, are shown to have improved its competitiveness in the domestic as well as global markets.

Rajesh K. Singh is lecturer and Suresh K. Garg is professor at Delhi College of Engineering. S.G. Deshmukh is professor at IIT, Delhi.

Small and Medium enterprises (SMEs) are recognized as a priority sector for development in almost all countries. In India, 95 per cent of industrial units (about 3.4 million) are in small-scale sector with 40 per cent value addition in the manufacturing sector; they provide dispersed employment to more than 20 million people across the country (second highest after agriculture), contribute about 6.29 per cent to the Gross Domestic Product and 35 per cent to Indian exports (Times of India, 2002).

The globalisation of markets, growing interpenetration of economies, and increased interdependence of economic agents are reshaping the international and national competitive environment. Manufacturing firms are under mounting pressure. These fundamental changes are prompting the farsighted organizations to reexamine and modify their competitive strategies. Indian organizations have often followed an opportunistic approach to growth, paying very little strategic attention to their shop floors. Rather they have followed a capability driven approach that seeks to strengthen key aspects of manufacturing (Chandra and Sastry, 1998). SMEs are not an exception. A study done by Chadha (1995) shows that in India, the number of SMEs is increasing every year. It is also observed that many SMEs are sick and are closing down regularly due to low product quality and rise in market competition (Subrahmanya, 1999).

Improving competitiveness of SMEs has become imperative for their survival because with state protection being withdrawn, SMEs hardly enjoy any distinction from larger units. However, SMEs may be differentiated from larger organisations by a number of characteristics (Table 1) (Marri et al, 1998, Tuteja, 2001, Dalu et al, 2001, Sardana, 2004). SMEs can normally operate with a single manager at the strategic apex. The flat structure of SMEs and fewer departmental interfaces normally result in a more flexible work environment. It is observed that SMEs are more responsive to market needs, more

adaptable to change, and more innovative in their ability to meet customers' demand.

Table 1: Characteristics of SMEs

• Flat and flexible structure
• Severe resource limitations
• High innovatory potential
• Informal dynamic strategies
• Low degree of specialization
• Top management highly visible
• Low degree of specialization
• Short decision-making chain
• Division of activities limited and unclear
• No specific budget for training of employees
• Individuals can see the results of their endeavours
• Can not cope with complex government regulations
• Efficient and informal internal communication network
• Personalized management, with little evolution of authority
• Ability to react quickly to keep abreast of fast changing market requirements
• Training and staff development is more likely to be adhoc and in small scale
• Can experience problems in coping with the time or costs involved in patent system

Opportunities and Challenges for SMEs after economic reforms

Economic reforms after WTO agreements have given many challenges to SMEs. These challenges may be due to small size, inadequate technology, location in rural and backward areas, difficulty in obtaining adequate and timely credit, inadequate standardization of products, processes, components, parts and sub assemblies etc, which discourage linkage between small and large units (Prasad, 1995; Armstrong and Coyle, 1999). A common conclusion from many studies is that small firms are often constrained by their very limited resources and ability to either acquire adequate information from external sources or utilize such information to evolve new operational practices (Robertson et al,, 1996).

The factory of future image is associated with advanced technologies enabling production of a variety of high quality products at low cost, delivered to the customers without delay (Boyer 1999). To achieve such goals, technological innovations are necessary. Technological innovations may involve several orientations such as: design based, manufacturing-based and administrative-based orientations (Ward et al,, 1994). Small enterprises may feel threatened by technological innovations that are not within their reach. To sustain their economic importance, small enterprises need support for defining their specific technological and organizational needs and then for finding the right approach to respond to these needs (Cagaliano et al,, 1998).

In spite of above challenges, liberalization of market has thrown open many opportunities for SMEs in all sectors, provided they are competitive. For example, according to a report in the Times of India (2003), domestic SMEs in auto parts industry are now witnessing a spate of enquiries from Turkey, China, Taiwan and Malaysia for sourcing technology and investment. Even Japanese, European and American vehicle makers are on the prowl. Japan and Europe are increasingly shifting their labour intensive work to low cost sites like India and China. Developed countries have already rendered themselves uncompetitive due to high prices, so the focus has now shifted to developing nations. Similar opportunities are coming for SMEs in other sectors such as plastic and electronics.

Initiatives needed by SMEs

To survive and prosper in this era of globalisation, SMEs need to establish mechanisms enabling them to exert conscious and sustained initiatives to continuously improve all facets of their operations. In an increasingly competitive market, SMEs have to search for new processes, new materials, new vendors, new shop floor designs, new channels to deliver products at competitive prices as well as increase the ability for networking and managing their limited resources.

The resource limitations associated with SMEs indicate that the dimensions of quality and time are critical to ensure that waste levels are kept low, and that a high level of productivity performance is attained. Similarly the reliance on a small number of customers suggests that to remain competitive, SMEs must ensure that customer satisfaction remains high. Learning how to build stronger relationships with customers is often recommended as a way of ensuring the survival of firms in the face of turbulent and highly competitive market conditions (Webster, 1992). In these situations where products and processes can be rapidly copied, the only real source of competitive advantage is stimulating learning by employees. This will assist these individuals to identify innovative ways of working, which in turn permits the organization to differentiate itself from competition. This attitude of learning is lacking in majority of Indian SMEs. The flatter structure of SMEs means that

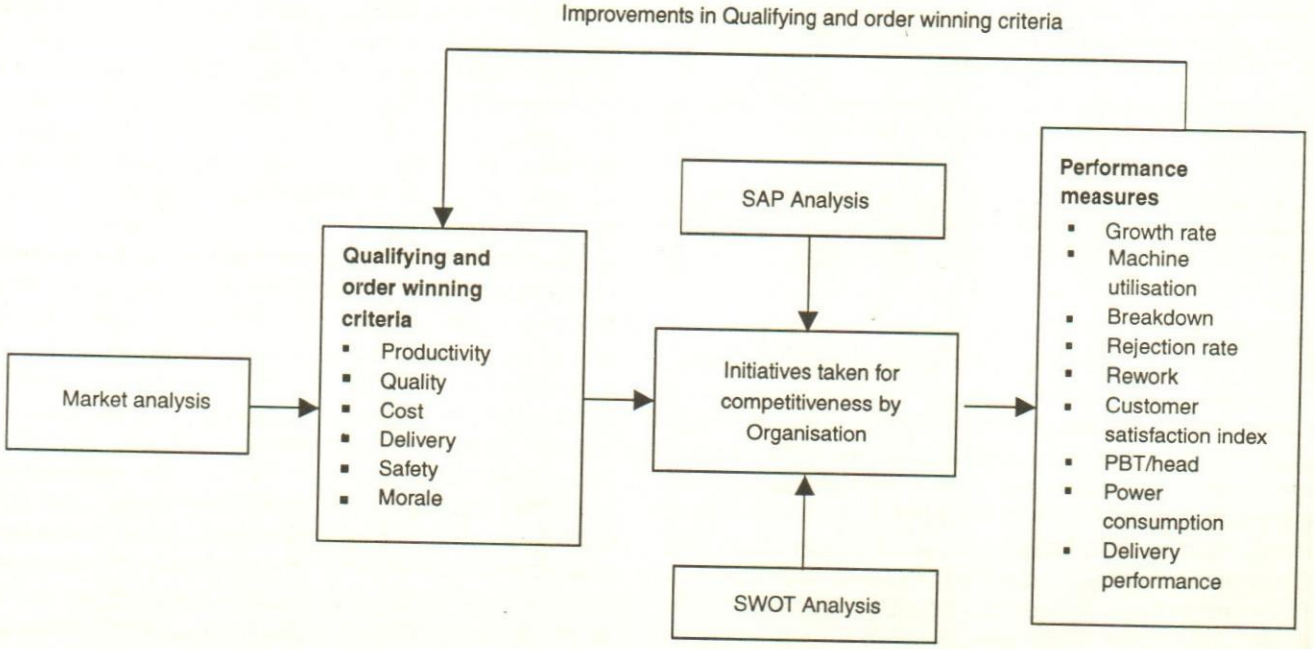


Fig. 1. Framework for study

employees often have a greater number of job roles and more responsibility. In these circumstances, a well-trained and motivated workforce is essential for effective monitoring of human resource dimension (Hudson et al,, 2001).

All kind of products sold or purchased by a firm are the result of a complex web of relationships between manufacturers, component suppliers, wholesalers, retailers and the logistic infrastructure that links them together. This web of trade relationships is known as supply chain or value chain (as each stage adds value to the product before passing it on). Value chain differs between trade sectors and even between firms within the same trade sector. The overall competitive advantage of an organization is not just dependent on the quality and productivity, but also upon its own supply chain. So for making any firm competitive in the market the whole value chain has to be competitive. For making whole value chain competitive linkages, different components of value chain have to be managed effectively. The efficiency of linkages may be enhanced by the use of information and communications technologies (ICTs). The internal systems, in turn, need to interface with suppliers and customers. Singh et al, (2003) have observed that SMEs using IT applications in their operations are benefitted in the long run.

In addition to the above requirements, SMEs should take initiatives to:-

- Identify and strengthen their core competencies.
- Continuously develop new products as the product life cycle has become extremely short
- Reduce substantially the inventory level
- Cultivate the organization culture for making employees quality and productivity conscious
- Cooperate globally (cross border investment and teaming up with counterparts in other countries)
- Be time conscious. The secret of the industries of China is that they are speed intensive. Therefore high-tech and low-tech industry have been replaced with high speed and low speed industry.
- Develop ability to capture or control scarce resources
- Learn about creation and sustenance of competitive advantages in their respective segment

Framework for study

A case study was conducted to identify the initiatives being taken by the organization to enhance its competitiveness. According to Cruz et al, (1992), competitiveness can be defined at three levels: country, industry/sector and firm as given in Table 2.

Focus of this study is on firm level competitiveness. The competitiveness of a firm depends on its ability to make appropriate choices of corporate and marketing objectives, based on a thorough knowledge about its market(s), and on its ability to use its total resources to

Table 2: Levels of Competitiveness

Country Competitiveness: Extent to which a national environment is conducive or detrimental to business.
Industry/Sector Competitiveness: Extent to which an industry or a business sector offers potential for growth and attractive return on investment.
Firm Competitiveness: Ability to design, produce and /or market products or services superior to those offered by competitors, considering the price and non-price qualities.

support the orders winning criteria. Hill (1995) distinguishes between three types of criteria, "order winning", "qualifying" and "order losing". Qualifiers are those criteria that a firm must meet to have a customer consider it to be a possible supplier, while the order winners are those criteria that win orders. Some qualifiers are more sensitive than others, because if the firm does not meet necessary standards on such criterion, it will lose the order and most likely also potential future orders. The roles of order winners and qualifiers are not stable. Based on actual requirements of customers/market, strengths and weaknesses, organizations should create an environment for continuous improvements. The framework proposed for this study is shown in figure 1.

Market analysis will provide information regarding order winning and qualifying criteria for a product. Based on information received from market analysis regarding order winning and qualifying criteria, SAP and SWOT analysis, organization would take various initiatives for improving its processes, infrastructure, technology and human resource. Priority for taking initiatives may change from firm to firm as well as with time. Effectiveness of initiatives taken by the organization will be reflected in terms of its performance. Performance measures of the organization will further help in reshaping of order winning or qualifying criteria.

Company Profile

The organization chosen for this case study XYZ ltd was established in 1979 and its growth has been generated by a paramount concern to provide result-oriented services to customer's specific needs. It is ISO9001, QS 9000 and TS16949 certified company. It is an umbrella company of a reputed group. It has a turnover of Rs 20 crore. It offers single window service through integrated facilities of Advanced Design centre with several seats of CAD/CAM/CAE, coupled with Mold flow analysis, Modern Tool Room with latest CNC machines from Europe and Japan with the capability of making moulds and dies up to 4 tons and has injection molding facilities to make in house plastic components as small as 1 gram and up to as big as 4000 grams.

The company is supplier to the Automotive, Electronics and White Goods Industries. Those who care for quality, service and just in time delivery are the regular customers of XYZ ltd. Main customers of the organization are General Motors, Ford, Delphi, Suzuki, Daewoo, Panasonic, Xerox, Canon, Whirlpool, LG Electronics, Gillette, Electrolux. It has export markets in Europe and America. Primary objective of the organization is to produce plastic components of global excellence, precision, durability and elegance conforming to end product requirements. This company is a member of the Automotive Component Manufacturers Association of India (ACMA), Plastic Export Promotion Council, Indo-German Chamber of Commerce, PHD Chamber of Commerce and Industry, Federaration of Indian Chambers of Commerce and Industry (FICCI), India Trade Promotion Organization (ITPO). The element of flexibility, coupled with fast responses, innovation, quality consciousness and responsibility towards the customers, have enabled the company to always keep its business partners happy and satisfied all over the world. This organization gives top priority to quality along with cost and delivery time.

Assets of the Organisation

Competitiveness is often derived from basic factors such as natural endowments. For instance, the competitiveness of the overseas ventures of Japanese firms has been derived mainly through factor endowments such as land and labour (Jain 1996). Firms having an advantage in factors such as labour cost, energy cost, transportation cost, have a better chance to compete in the market. These factors are called assets of the organization.

Factor Cost

For any organization to be competitive in the market, advantage in terms of labour cost, raw material cost and energy cost plays a crucial role. XYZ does regular evaluation of labour cost, raw material cost and energy cost with its competitors. Labour rate, energy rate and raw material cost (% of sales) for this organization are Rs 3500/month/employee, Rs 3.50/KWH and 72.68% respectively in comparison to Rs 3600/month/employee, Rs 3.50/KWH and 70% for its national competitor.

Logistic Factor

The physical distance of a supplier and customer from the organization has a significant effect on transportation cost. Distances of its suppliers and customers from XYZ are shown in Figure 2. Most of the suppliers are in the vicinity of less than 100 Km, whereas most of the

customers are at a distance of 30 Km. Daily stock check is kept through e-mail by the logistic department and a minimum stock level is always kept in line to feed the customer line. In this case, the logistic department of XYZ ensures the ready availability of the stock.

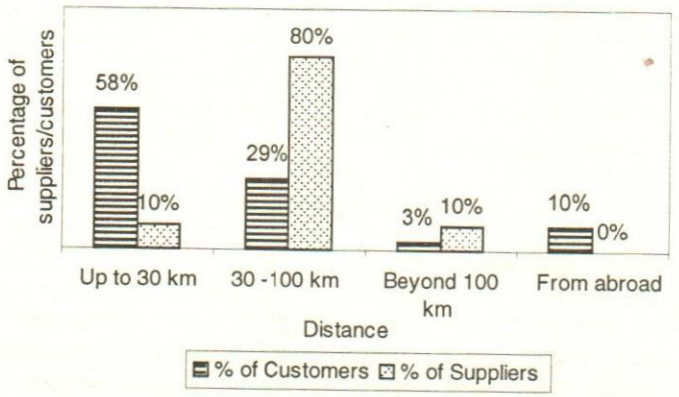


Fig. 2. Location of suppliers/customers

Technological Factor

This organization has technical collaboration with a European company. It has its own tool room, in which they have number of high tech machines, which include Injection Moulds, Precision Moulds, Die Casting Tools, Prototype Moulds, Hot Runner Moulds, Stamping Dies, latest CNC machines from Switzerland and Japan of the same standard as available in the most advanced countries of the world, conventional machines from reputed Indian suppliers, mould making capacity up to four tons. In the design centre for doing precision engineering they have CAD / CAM / CAE - I-DEAS compatible with CATIA, PRO-E & UNIGRAPHIC, MOLDFLOW - Flow, Cool, Warp, Shrink, Gas. They also have ISDN Link and are capable of doing Reverse Engineering. In addition to the above, other advanced machines available are CNC, EDM Roboform, CNC Wirecut Robofil, Vertical Machining Centre, EDM-spark erosion, Lathe turn master 35 kirloskar, lathe Turn master 40 kirloskar, Milling machines and polishing machines.

SAP Analysis for Organisation

SAP (Situation, Actors and Processes) analysis is carried out to analyse the present external and internal environment (situation), actors involved in decision-making, policies, methods and processes being practiced by the organization. For this organization, this analysis is as below.

S-Situation

- Supplier of top three home appliance companies i.e. L.G, Samsung and Electrolux.
- For LG, the product range is wide; schedules are unpredictable, leading to lack of proper planning, frequent changes of schedule and delay in delivery.
- For Samsung, high line rejections, prevents the on time delivery of goods.
- Distance from Electrolux and Kelvinator is more, therefore delivery to these customers is delayed due to logistic factor.
- Immense pressure to reduce 10% cost annually.
- Customer expects Japanese quality, Chinese price and Western technology from vendors.
- Machine utilisation has been low
  (a) Due to non-availability of raw material at right time from certain plastic material suppliers and due to frequent changes in schedules.
  (b) Absence of SMED (Single minute exchange of dies).
- In year 2002-03, the breakdown percentage was quite high i.e. 7.8%.
- Accidents constituted 30% of the total breakdowns.
- High line rejections of the order of 1200ppm. For some customers this rejection rate is up to 20000ppm. It is due to new product development and sudden changes in their products.
- In year 2001-02 rework percentage was 1.69% of the total production.
- Average age of employee is 27 years that means work force is young and enthusiastic.

A-Actor

- Technical decisions are taken by Senior Technical Division.
- Company overall decisions are taken by Vice President for future development and oversees market.
- Department heads are also authorized to take developmental decisions in consultation with the other management heads.
- Employees are encouraged to participate in decision making through Kaizen and quality circles.
- Customers, suppliers and logistics players are also involved in decision making.

P-Processes

- Mould designs are prepared by using softwares such as IDEA (8seat) and Mould flow.

- Reducing inventory level through ABC analysis.
- Supplier rating and assistance in development of required quality.
- Training and supplier rationalization.
- Outsourcing to increase product range without investing on new machines. Presently 32 moulds run outside the company.
- Improvement of operators through cross-functional teams.
- Customer satisfaction surveys for internal and external customers.
- Application of simple techniques like Just In Time (JIT), Total Quality Management (TQM), Bench marking, Plan, Do, Check and Act (PDCA) cycle for better performance.
- Practicing design of experiment (DOE) to reduce the cycle time and eliminate the waste by achieving optimum set of working environment.
- Association with plastic export promotion council, FICCI, ITPO, ACMA and Indo German chamber helps in benchmarking against market leader in the world. Targets are set and action plans are made to achieve the technical, production, and quality targets. Targets are reviewed monthly and revised annually as per the requirement.
- TQM techniques such as 5S, 3M, 3G, Kaizen, quality circles etc are practiced.
- 5S is related to assigning the place of every thing and keeping the things at right place. In this organization a six-month exercise is carried out to identify the necessary and unnecessary things. Unnecessary things are donated or discarded while the necessary things are kept at the places as per usage frequency. As a part of this practice the company offers one machine to one operator to build a sense of self-ownership so that he should clean his area etc. Apart from this 5S audits are also conducted both by internal and external auditors.
- 3M is the philosophy of removing waste, strain and discrepancy from manpower, techniques and facilities.
- 3G philosophy of approaching the stage of problem, analyzing the problem and taking appropriate action is also observed.
- Statistical process control charts are used to control critical process parameters.
- At the time of induction of new employees and also during the annual appraisal, a gap analysis is done regarding the required and acquired skills, on the basis of which the annual training calendar is made to impart training to all the employees. This process of training is shown in figure-3.

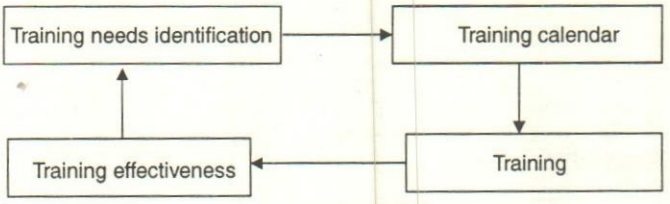


Fig. 3. Training Methodology

SWOT Analysis

Research has shown that SMEs, which link operations to their business strategies, outperform the competition (Argument et al, 1997). For formulating effective business strategies, SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis has emerged as an effective management tool for Indian SMEs (Singh et al, 2004). As a part of this exercise, this organization also does its SWOT analysis at regular intervals of every 2 years as shown in Table 3.

Table 3: SWOT Analysis for XYZ Ltd

S-Strengths	W-Weakness
Good will in market. Part of reputed Group. Diversity in production. Favourable capital output ratio.Fully equipped tool room. In-house tool room with injection molding machine. They work from designing to final product. Product realization is done on the concept basis.	Production is totally depending on other firms (customer). Under-utilization of machine. Not using management practices like TPM, Kan-ban etc. Quality rejection rate is high.Lack of high skilled manpower and specialists.
O-Opportunity	T-Threat
Growing home appliances market.Shifting trends from sheet metal to plastic.CATIA, Image ware and coming up high trend software. Increasing product range.	Fully dependent on MNC. Polypropylene is an environment hazard and in future they have to choose other materials for their product. No product of their own. Competition from large multi-nationals. Increase in price of inputs.

Initiatives taken by Organisation

On the basis of market analysis, SAP and SWOT analysis, XYZ ltd takes initiatives for improving its competitiveness. The competitiveness of a firm could be described in terms of its ability to win orders on the market. The competitiveness of a firm depends on many factors. According to the framework given by Hill (1995), an organization needs to take five steps for

developing competitive strategies. The first is to define the corporate objectives (for example ROI, profit, growth). The next steps are to determine a marketing strategy to meet these objectives, analyse how different products win orders on the market against competitors and to establish an appropriate manufacturing process and infrastructure to support the competitiveness of a firm.

To implement its strategies effectively with regard to customer satisfaction, application of new technology, foolproof processes and development of its human resources, some of the initiatives taken by this organization are as follows:

- Efforts have been made to attract new customers by investing in CAD /CAM and design facilities.
- Company has taken various six sigma projects to reduce line rejections. For this they are taking the help of their customer like LG. Under the six-sigma project the employees are trained on basic six sigma concepts and all the technical staff is involved in problem solving.
- Arrangements are being made to setup a new production centre near some of the far away customer plants such as Samsung and Electrolux.
- It is developing new strategies to diversify into new products like monitor cabinet.
- Exploring new export market in America and Europe.
- Doing market survey to formulate strategy to develop their own product to shift from total customer based company.
- It has formed International Business Development (IBD) by recruiting three members to achieve an export target of Rs 3 crore per annum.
- Information Technology application has helped to lower down the product development lead-time and delivery time.
- Working towards paperless office and daily morning meetings to overview the daily targets and proper planning.
- Company is buying latest technology machines to give quality product.
- Preventive maintenance of machines is done as per annual preventive maintenance plan. Company has taken some measures to reduce the breakdown time as follows:

  (a) Gradual replacement of old machinery having a history of frequent breakdowns.

  (b) Installation of safety devices like proximity sensors to prevent the accidents.

  (c) Annual maintenance contract of critical and new machines has been given to suppliers of the machines. Further TPM activities are also initiated along with annual preventive maintenance.

- Implementation of Poka yoke i.e. fool-proofing in the tools and fixtures by the application of sensors (PLC), pneumatics and limit switches.
- Actions taken to improve process plan of a particular product through cross-functional teams.
- To compensate increase in power consumption, utilization of generator and state electricity in proper ratio and automatic switching off of heavy power consuming machineries during idle time.
- For safety purpose, mock drill is performed. In this, fire is ignited in any decided area of the organization and then the action of all concerned people are keenly studied. Accordingly documentation is done and corrective action is taken.
- Proper insulation on the barrels of injection moulding machines was done to avoid dangerous fumes from them. Various safety devices like fire extinguishers were provided at proper places and were properly maintained.
- Plant lay out was laid giving consideration to safety. For example, defined workplaces, broader exit gates, and proper number of exhaust fans etc were taken care of.
- This organization has increased training time of 5 hours/employee/year to 9 hours/employee/year.
- Birthday celebrations are done by the company for each employee.
- Full attendance awards are given to employees who are regular and do work with full integrity
- Reduction of overheads and wastage through improvement in malfunctioning processes.
- Increased accountability of individuals by daily management.
- To sustain pressure of continuous cost reduction, the company is adopting a policy of motivating their employees for innovative ideas.

- It has clearly defined key indicators for measuring performance of different departments.

Performance

Competitiveness of an organization depends on its overall performance. For measuring overall performance, financial as well as non-financial measures are required. Financial measures are generally viewed as describing the current status of a firm and reflect the consequences of past decisions or actions. These are important for comparing a firm's current success with those of competitors, although they do not offer a clear view of the future success of the firm. To judge a firm's performance in a thorough performance analysis, qualitative and quantitative non-financial measures should be also considered (Yurdakul, 2003). Performance of this organization in terms of some factors can be stated as below:-

- Sales growth has increased from Rs 0.05 crore per head in 2000 to Rs 0. 103 crore per head in 2003.This has been due to inclusion of new customers and by increasing the range of their products.
- Machine hour utilization has increased from 57.53% in 2000 to 85% in 2003.
- Breakdown percentage has decreased from 7.80% in 2000 to 2% in 2003.
- Internal PPM rejection has come down from 25400 in 2000 to 5000 in 2003.This has been achieved due to implementation of six sigma programmes.
- Rework percentage has come down from 1.69% in 2000 to 0.15% in 2003.
- Customer satisfaction index has increased from 67% in 2000 to 92% in 2003.This has been possible due to various measures taken such as installation of up to date facilities and feedback from customers regularly.
- Profit before tax (PBT) per head has increased from Rs 30061 in 2000 to Rs 44640 in 2003.
- Cost of poor quality flash has decreased from Rs 1.87 lakhs in 2000 to Rs. 0.7 lakhs in 2003.
- Sales turn over has increased from Rs 2 crore in 2000 to Rs 20 crore in 2003.This has been due to inclusion of new customers and by increasing the range of their products.
- Annual power consumption has increased from 60000 KWH in 2000 to 180000 KWH in 2003. This increase has been due to induction of new machines like CNC lathes, milling and other tool room facilities and increase in production/sales.
- For Sony and Samsung it has delivery on time index 90%, for others such as LG, Electrolux etc it is 80%.

Performance of this organization in 2003 in various counts can be summarized as shown in Table 4.

Table 4: Performance of the organization in terms of various factors

Performance Measures	Value in 2000	Value in 2003	Percentage change
Sales growth/head (Rs crore)	0.05	0.103	106 (+)
Machine hour utilization (%)	57.53	85	27.47 (+)
Break down percentage	7.8	2.0	74.35 (-)
Internal rejection rate (PPM)	25400	5000	80.31 (−)
Rework percentage	1.69	0.15	99.91 (−)
Customer satisfaction index (%)	67	92	37.31 (+)
Profit before tax/head (Rs)	30061	44640	48.49 (+)
Cost of poor quality (Rs lakh)	1.87	0.7	62.56 (−)
Sales turn over (Rs crore)	2.0	20.0	900 (+)
Annual power consumption (KWH) x 10^3	60	180	200 (+)

(+) Increased, (−) Decreased

Concluding Remarks

SMEs play an important role in the economic growth of India. Before economic reforms these units were surviving even without being competitive in the domestic or global market. These SMEs were dependent mainly on old technology with little orientation for emerging management tools. The present scenario of hyper competition has forced SMEs to reform their old thinking as evident from this case study.

Now R&D, IT applications, TQM, JIT, SCM, WCM, Six sigma are not confined to only large scale organizations as earlier but it has become part of SMEs regular functioning. SMEs cannot be differentiated from large-scale organizations in terms of these areas in spite of their limited resources. From this case study it is also evident that awareness among SMEs for competitiveness has improved. They are taking initiative for improving quality, product-developing capability, IT applications and finally human capital, in order to improve their performance in the market.

References

Argument, L, Harrison, D and Wainwright, C. (1997), "Manufacturing strategy within the SME sector", 13th National Conference

of manufacturing (Proceedings), Glasgow Cledonian University, Glasgow, pp. 6-10.

Armstrong, P.J. and Coyle, P. J. (1999), "The relevance of enterprise resource planning to manufacturing SMEs" Proceedings of the 15th International Conference on Production Research, Limerick, Ireland, pp. 721-726.

Boyer, K. K. (1999), "Evolutionary patterns of flexible automation and performance: a longitudinal study", Management Science, Vol.45, No. 6, pp. 824-842.

Cagliano, R, Spina, G, Verganti, R and Zotteri, G. (1998), "Designing BPR support services for small firms" International Journal of Operations and Production Management, Vol. 18, No. (9/10), pp. 865-885.

Chadha V. (1995), "Technological modernization of small sector in India", Productivity, Vol. 36, No. 3.

Chandra, P and Sastry, T. (1998), "Competitiveness of Indian manufacturing", Vikalpa, Vol. 23, pp. 25-36.

Cruz, D.J and Rugman, A. (1992), "New Compacts for Canadian Competitiveness", Kodak, Canada.

Dalu, R.S, Deshmukh, S. G. (2001), "SWOT analysis of small and medium scale industry: A case study", Productivity, Vol. 42, No.2, pp.201-216

Hill, T. (1995), "Manufacturing strategy, Text and Cases", Macmillan Business, Basingstoke.

Hudson Mel, Smart Andi and Bourne Mike (2001), "Theory and practice in SME performance measurement systems", International journal of operations and production management, Vol. 21, No. 8, pp. 1096-1115.

Jain, A (1996), "Entering the Asian Market: Technology Strategies of Japanese Companies", Asia Pacific centre for Technology Transfer, October.

Marri, H., Gunasekaran, A and grieve, R. (1998), "An investigation into the implementation of computer integrated manufacturing in small and medium sized enterprises", International journal of advanced manufacturing technology, Vol.14, pp. 935-42.

Prasad C. S. (1995), "Export Potential of Small Scale Industries", Productivity, Vol.36, No. 1, pp. 53-59.

Robertson, M, Swan, J. and Newell, S, (1996), "The role of networks in the diffusion of technological innovation", Journal of Management Studies, Vol. 33, No.3, pp.333-59.

Sardana, G. D. (2004) "Determinants of SME Success: Formulating a Business Strategy", Productivity, Vol. 44, No.4, pp. 572-585.

Singh R K, Garg S K and Deshmukh S G (2003) "Information technology for small and medium enterprises: Some considerations", International conference on CAD, CAM, Robotics and Autonomous Factories at Indian Institute of Technology, Delhi.

Singh, R. K, Garg, S. K. and Deshmukh, S. G. (2004), "Competitiveness of Small and Medium Enterprises: Case of an Indian Auto Component Manufacturing Organization", IIMB Management Review, Vol.16, No. 4, pp 94-102.

Subrahmanya, M. H. Bala. (1999) "Shifts in India's small industry policy", National Bank News Review, July-September, pp. 27-37.

Times of India (2002), "Small Scale Sector: an engine of growth", October 24, Delhi.

Times of India (2003), "Firms eye India for auto sourcing" January 24, Delhi.

Tuteja, S.K. (2001), "Characteristics and contribution of SMEs", NPC International forum for SMEs, August 20-29, Delhi.

Ward, P., Long, G. K. and Boyer, K.K. (1994), "Manufacturing proactiveness and performance". Decision Science, Vol. 25, No. 3, pp. 337-358.

Webster, F.E. (1992), "The changing role of marketing in the corporation", Journal of Marketing, Vol.56, October, pp. 1-17.

Yurdakul, M. (2003), "Measuring long term performance of manufacturing firm using the Analytic Network Process (ANP) approach", International Journal of Production Research, Vol. 41, No. 11, pp 2501-2529.

□

Life is like a game of cards. The hand you are dealt is determinism; the way you play it is free will.

– Jawaharlal Nehru

Feature

Managerial Effectiveness Through IT

V. Nanda Mohan & V. Ajayakumar

IT enabling of an organization is a long process, sometimes taking years. A model suitable for the Indian context has to be evolved after taking lessons from the IT-enabling exercises carried out successfully. A graphical representation of the IT strength of an organization is attempted in this paper. An objective of this study is to suggest a model indicating the relationship between the IT strength of the firm at various stages of its information system development and the managerial effectiveness in terms of profit.

V. Nandamohan is Professor & Head, Dept. of Future Studies and V. Ajaykumar is Director, Computer Centre, University of Kerala, Thiruvanthapuram, Kerala-695034.

The IT strength of a firm is based on the hardware and software being used by the firm, the service of IT professionals available for the firm, the order of events for the information system development, the nature and purpose of information sharing with other organizations etc. The data needed for the study were collected from Indian organizations, which have undergone IT-enabling during the late 1990s. A large number of IT-enabled firms were covered in the survey, but only 40 firms gave almost all details for the study and so the sample was limited to those 40 firms. Data on the performance of the firms before computerization and after computerization (each covering three years) were considered for analysis. The study covered both manufacturing and service sector firms. The managerial effectiveness has been measured in terms of profit margin obtained as a percentage of capital (fixed and working). The IT-related factors influencing the performance of the firms in each category has been identified using regression analysis.

The G-Score Index

The index has been developed based on five broad constituents: infrastructural, software, personnel, managerial and transformational and each one is divided into sub-constituent variables as given below

Infrastructural

- hardware facilities
- network infra structure
- uptime index of the systems
- government policies

Software

- software architecture
- computer expertise
- software index

- adequacy of appropriate software

Personnel

- attitude of employees
- nature of training given to managers
- computer and management qualifications
- degree to which managers resort to general automated solutions

Managerial

- usage of management software for financial analyses, market research etc.,
- management expertise available in the organization
- authority of computer professionals
- urgency of the IT solutions

Transformational

- degree of diffusion of technology into the firm
- organizational levels
- the nature of digital connectivity of the firm to the external world
- percentage of revenues from the new IT-based services or products etc.

The hardware facilities, network infrastructure, uptime index of the systems and government policies form the first group called *infrastructural*. The sum of the scores obtained in these areas is called *infra score*. Information architecture, effective computer expertise, software index and adequacy of appropriate software are grouped under the head, *software*. The design of the information architecture should be completed well before the commencement of software development. If the software procured by the firm is not appropriate to its requirements, the IT strength of the firm will be poor even if the software index of the firm is high. Adequacy of appropriate software is included as a study variable to consider this aspect of the system. The extent of system study is a measure of the attempt to design information architecture. The attitude of employees, nature of training given to managers, expertise in both computer and management areas and the degree to which managers resort to general automated solutions are components of the category, *personnel*. Usage of specific management software for financial analyses, market research etc., effective management expertise available in the organization, authority of computer professionals and the urgency of the IT solutions are study variables included in the fourth group.

The variable degree to which managers resort to general automated solutions is different from usage of specific management software in the sense that the former refers to general use of computer systems by managers, but the latter is related to usage of specific management software for market research, financial analysis etc. The authority of the computer professionals depends on the hierarchical level in the organization where he/she is placed. Since salary is an index of such a level, the salary difference with reference to the highest paid manager is assumed as a measure of authority. *Management score* is computed by adding together the values obtained for the four variables listed above. The *transformational* aspect covers the organizational changes required, the nature of digital connectivity of the firm to the external world, degree of diffusion of technology into the firm and percentage of revenues from the new IT-based services or products etc. *G-score is* found out by adding together infra score, software score, personnel score, management score and transformational score.

Of the different sub-constituent variables of G-score index, hardware facilities, network infrastructure, uptime index of the systems, software architecture, authority of computer professionals, organizational levels and the new IT-based services, are study variables comparable to factors considered in the study of Kanungo (1999).

Strength of firms over different phases

This section gives an account of the analysis of the strength of firms over different phases of IT enabling. The variables considered for the estimation of composite index, G-score are used in this analysis.

In fact, five phases are perceived in the growth of the information system of an organization, which are *design of the system architecture, development of transactional systems, internal integration & development of management information systems, installation of inter-organizational databases and redefinition of business scope through global network*. The approach taken for the definition of the phases is different from that of the previous studies. The stages in the Nolan Model are those through which an ordinary information system normally passes through because of many factors, including slow technology diffusion. Now that technology is more easily available in the areas of IT application, organizations can act according to a properly planned IT architecture. The phases proposed in this study are those which a firm with proper IT plan-

Table 1: IT strength at various phases

	Infra Score				Software Socre				Personnel			
Stages	Hardware	Environment	Funds and policies	Percentage of networked computers	Design of architecture	Eff. Comp expertise	Software index	Appropriateness of software	Attitude of employees	Nature of training	Expertise in both comp & management areas	Aptitude for using computers
S1			0.428571		0.428571	0.491961			0.857143		0.281573	
S2			0.428571		0.428571	0.491961	0.482315		0.857143		0.281573	
S3	5.780535	0.75	0.428571	0.257143	0.214286	0.491961	0.482315	0.857143	0.857143	0.428571	0.281573	0.337621
S4	5.780535	0.75	0.428571	0.514286	0.428571	0.491961	0.482315	0.857143	0.857143	0.428571	0.281573	0.337621
S5	5.780535	0.75	0.428571	0.514286	0.428571	0.491961	0.482315	0.857143	0.857143	0.428571	0.281573	0.337621

	Managerial				Transformation				
Stages	Usage of management software	Expertise of managers	Authority of Computer professionals	Urgency of the solution	Nature of organisational levels	Nature of digital connectivity	Knowledge of technology	Revenue from IT based products	Strength of firm at different phases
S1		0.572347	0.5	0.571429		0.214286	0.857143		5.203024
S2		0.143087	0.5	0.571429		0.214286	0.857143		5.256079
S3	0.942857	0.572347	0.25	0.285714		0.214286	0.857143		14.28921
S4	0.942857	0.572347	0.5	0.571429	0.857143	0.857143	0.857143		16.79635
S5	0.942857	0.572347	0.5	0.571429	0.857143	0.857143	0.857143	0.714286	17.51064

ning can pass through to maximize the benefits available from technology. The *business process redesign,* being considered an important phase after *localized exploitation* and *internal integration* in previous studies, is given due importance in the first phase itself. The five phases may not be distinct, if the design of the information system architecture is effective.

Since a variable will not have significance at all the stages of growth, the value of a variable is considered only at those stages where it has got significance. The sum of the values of those variables found significant in the first phase is taken as the strength of the firm for that phase. Table 1 shows the values of strength components at each phase. The strength at all the five phases of a firm are thus found out. A graph of strength vs. phases is drawn for each firm.

Also, firms are classified as low performance, medium performance and high performance, in terms of profit. Most of the manufacturing firms of the low performance category are found to have very low initial strength and slope. The high performing firms are found to have higher initial strength and greater average slope. The relation between initial strength and greater slope is more pronounced in service firms. In general, a firm with higher initial strength is seen to have greater slope and better performance. *The importance of completing the design of information system architecture before the procurement of hardware and development of software is emphasized by these graphs.*

Firms showing greater slopes in phase 2-3, in spite of low initial strength, are capable of exploiting the automated system for effective Management Information System (MIS) report generation. Poor strength of some of these firms in later phases means that they are not capable of reaping benefits from inter-organizational database or transformational aspects of information system. A firm with relatively high initial strength and low slope will be able to get the benefits due to the initial stages of development of information systems. Such a firm may be under-utilizing some of the resources at initial stages. An ideal firm will have a system with a reasonably good level of initial strength and increasing gradient at later stages (Table 2).

Manufacturing firms of the low profit category have low initial strength and an average slope of approximately one unit. From the graph it can be predicted that these firms are capable of automating some of the transactional functions and generating a few reports. The conversion of these firms into totally IT-enabled organizations may require huge investments in terms of men and machines. A new system study and design of information architecture are also necessary.

	firm 1	firm 2
S1	5.444888	2.766542
S2	5.825794	2.9991
S3	12.40152	4.934707
S4	14.90866	5.706135
S5	15.90866	6.277564

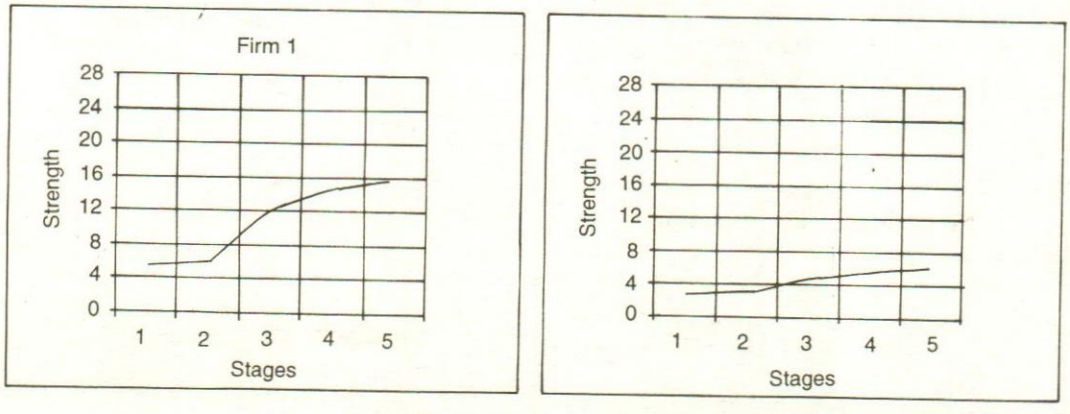


Fig. 1. Sample logistics

Manufacturing firms of medium profit category have an approximate average initial strength and gradient of 5.3 and 2 respectively. Most of these firms can develop Management Information Systems with limited capabilities. These firms in general do not have the capability of setting up inter-organizational databases or redesigning their business scope using global network. Manufacturing firms of the high profit category have an average initial strength greater than 5 and an average slope greater than 2. Typical characteristics of fully IT-backed firms are not seen in these firms though they are comparatively stronger than those of other two categories. Figure 2 shows the families of curves representing IT strengths of firms of low, medium and high profit levels. This makes explicit that managerial performance in terms of profit is more related to IT strength.

Table 2: Logistics of Different firms

Type of firm	Profit level	Average initial strength	Average final strength	Average slope
Manufacturing	low	4.11	8.77	1.16
	medium	5.31	13.3	2.01
	high	7.49	16.33	2.21
Service	low	3.28	8.85	1.39
	medium	7.31	15.4	2.02
	high	12.93	22.23	2.32

Service firms of low performance category have an average initial strength, which is less than 7 and slope less than 2. These firms maintain automated systems with limited scope. Service firms of medium profit category have an average initial strength of 7.3 and an average slope of approximately 2. These firms can generate reports needed for managerial decision-making. These firms have limited capabilities to develop and maintain organizational databases and business scope redesign. Service firms of high profit category have an average initial strength much higher than 7 and an average slope greater than 2. Only two firms have a marked increase in slopes, showing greater strength for internal integration and development of management information systems. These firms can develop good IT-backed information networks. The firms with high initial investment and low average slope have underutilized IT investments. Table 2 shows the average values of initial strengths, final strengths and slopes of firms belonging to each category.

Conclusion

A model for information system design can never be a static one. Since technology is the chief enabler for computer–based information systems, any advancement in technology will have its own influence on the design of information systems. Now that the potential of IT is known to designers, business process redesign need not be considered as a separate stage in the infor-

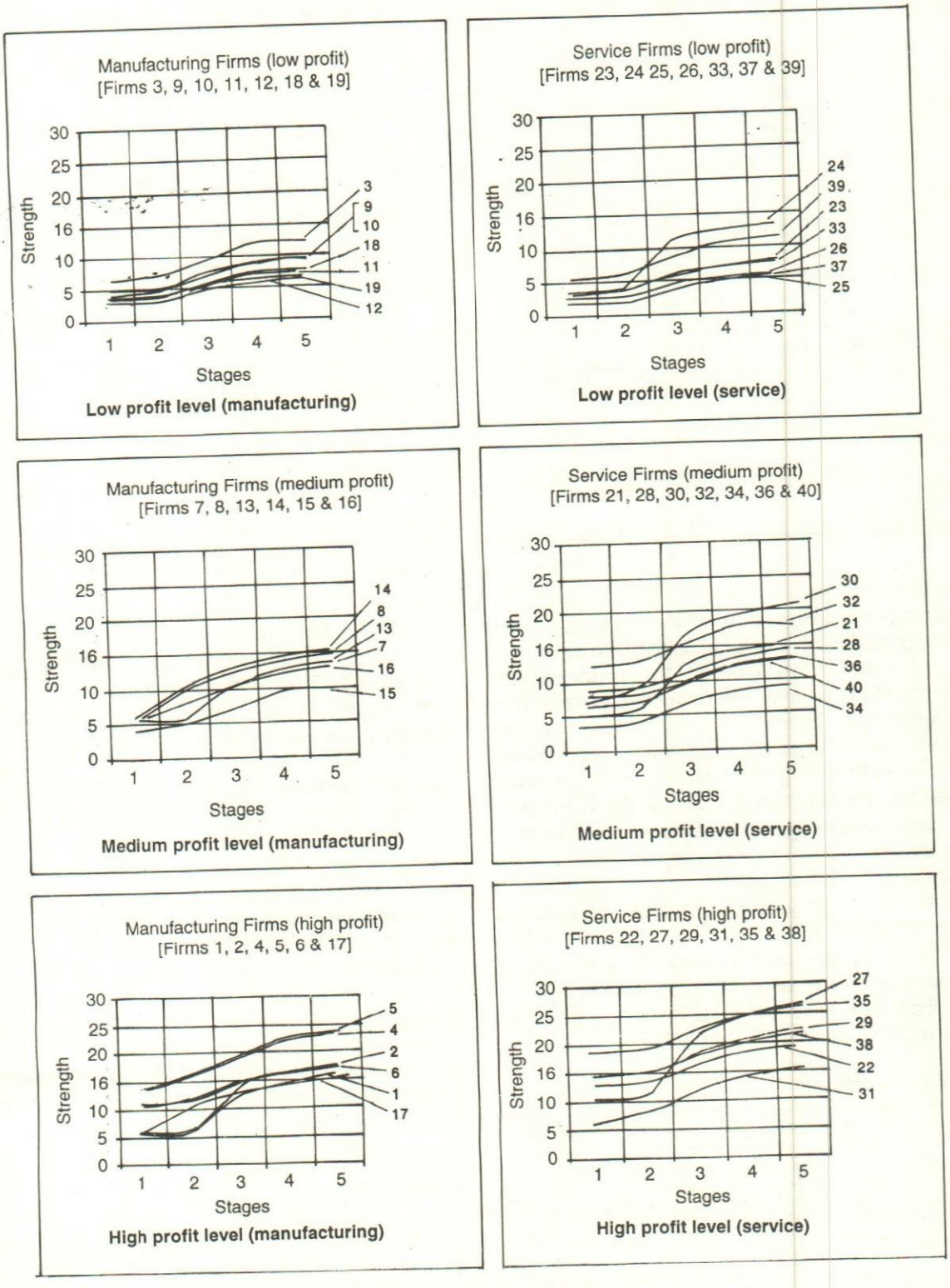


Fig. 2. *Logistics of various firms*

mation system design process, as it is part of the design of the information system architecture. The models *described in reference 4 show the different stages* through which conventional information systems matured. The more powerful information technology tools *available now facilitates better design of information*

systems. A new model for the IT enabling process has been developed as part of this study. The main stages of this model are design of information architecture, development of transaction systems, internal integration development of management information systems, design of inter-organizational databases and business scope redesign. The software development in the second stage is in accordance with the design completed in the first stage and is in anticipation of the requirements of the third and fourth stages. The stages suggested in this study form a model of design, which fully utilizes the potential of technology available now.

This study proposes a specific order for the events related to IT-enabled activities. Computer hardware and communication tools needed for the deployment of the software need be procured only in the second half of the second stage. This can minimize the problems due to underutilization of hardware resources and the probability of the system getting obsolete. The facilities for building up inter-organizational databases can be effectively used only after full-fledged information systems based on powerful database engines have been made fully operational. This factor is very important since the cost of installation of infrastructure for the development of inter-organizational databases is more than that of the information system development in individual organizations. Such information systems over time can also facilitate the development of a knowledge management system in the organization which can induce a cumulative growth process in a sustainable way.

References

Shivraj Kanungo (1999), "Making Information Technology Work", Sage Publications, New Delhi. □

Imagination is more important than knowledge. The important thing is to not stop questioning.

– Albert Einstein

Feature

Gender and ICT: Towards an Analytical Framework

C. Vijaya

This paper presents a range of perspectives on gender, information and communication technology (ICT) drawn from a review of the literature. The aim is to present some of the major debates and critiques of ICT to highlight some important issues of concern for women. It also provides an analytical framework from which to view women's global participation in computer networking.

C. Vijaya is Faculty Member, RICM, Kalyani.

Judy Wajcman's book "Feminism Confronts Technology" concludes, "The time is ripe for reworking the relationship between technology and gender. The old masculinist ideology has been made increasingly untenable by the dramatic changes in technology, by the challenge of feminism... Technologies reveal the societies that invent and use them, their notions of social status and distributive justice. In so far as technology currently reflects a man's world, the struggle to transform it demands a transformation of gender relations".

Before embarking on a discussion of gender and ICT, it is important to clarify what is meant by the terms. According to Wajcman, 'technology' has at least three different layers of meaning (p. 14). First, 'technology' refers to what people know including the know-how to use technology, repair it, design it and make it. Second, 'technology' refers to the human activities and practices of technology such as steel making and computer programming. And finally, 'technology' refers to the hardware or the sets of physical objects such as computers or cars.

Swasti Mitter (1995) differentiates 'information technology' as a group of technologies that process rather than merely store or transmit information. At the core of information technology are computers and software.

According to Pilar Riano (1994), the term 'communications' refers to "a social system of shared symbols and meanings (which) binds people together into a group, a community, or a culture".

The term 'gender', on the other hand, refers to the different roles men and women play in a society or a community. These roles are determined by cultural, social and economic factors and differ within and between cultures and countries. Sheila Rowbotham (1995) observes that the term 'gender' has no single meaning, but

is affected by a whole complex of social relationships . Gender roles are different from sex differences in that sex differences are biological, and for the most part, unchangeable. Gender roles are dynamic and change over time (UNDP).

Feminist Perspectives

One of the first things pointed out in the gender and technology literature is that women's contributions to the field have been left out of history. The task of early feminist scholars, therefore, has been to "uncover and recover the women hidden from history" who have contributed to technological developments (Wajcman, 1991). In identifying women's history, writers point to evidence that during the industrial revolution women invented and contributed to the invention of such crucial machines as the cotton gin, the sewing machine, the small electric motor and the loom. Similarly, feminist work on the history of computing and information technology draws attention to the fact that women have always been involved in computing. To fully comprehend women's contributions to technological development, these writers argue for a movement away from the traditional conception of technology (which sees technology in terms of male activities) to a greater emphasis on women's activities.

Women in Technology

The 'women in technology' literature focuses on women's exclusion from technology, with change understood as coming about via increased access and further equal opportunities policies. Early studies of women and the engineering, computing and information technology sectors draws attention to women's under- representation in technical occupations and their over- representation in operator and clerical jobs. Although more recent studies show women making some inroads into technical and higher level occupations, there is an increasing feminization of some of the lower level jobs. Educational data, too, show a distinct gender pattern with women representing a small and declining proportion of entrants to university computer studies courses. Studies on the conditions of work for women in technology draw attention to salary differences which show women earning less than men (Henwood, 1993). The solution to these problems from the 'women in technology' perspective is to increase the numbers and proportion of women in computing and information technology.

A Technology Based on Women's Values

In the 1980s, feminists turned their attention to the gendered character of technology itself. "Rather than asking how women could be more equitably treated within and by a neutral technology, many feminists now argue that Western technology itself embodies patriarchal values" (Wajcman, 1991). Technology, like science, is seen as deeply implicated in the masculine project of the domination and control of women and nature. The argument from this perspective is for a technology based on women's values. Eco-feminists' critiques of technology have been particularly visible from this perspective concentrating on military technology and the ecological effects of modern technologies, which they view as products of a patriarchal culture. Feminists from this perspective promote women's greater humanism, pacifism, nurturance and spiritual development and seek a new vision of technology that would incorporate these values.

Technology and the Division of Labour

Building on the Marxist labour process debates of the 1970s (which saw the social relations of technology in class terms), technology from this perspective in understood as neutral but misused under capitalism to deskill workers and increase managerial control over the labour process. Feminist contributions to these debates see women's exclusion from technology as a consequence of the gender division of labour and the male domination of skilled trades that developed under capitalism. As Wajcman points out, women's alienation from technology is accounted for in terms of the historical and cultural construction of technology as masculine. Thus, technology from its origins reflects male power as well as capitalist domination.

Gender and Technology Socially Defined

Rejecting the notion that technology is neutral, this perspective understands technology and gender as socially defined. Historically, technology has been defined as exclusively male activities in such a way that many tasks women have traditionally performed (such as knitting) are not defined as technical despite involving a high degree of manual dexterity and computation (Cockburn, as quote in Henwood, 1993). Similarly, Game and Pringle point to distinctions such as 'heavy/light', 'dirty/clean', and 'technical/non-technical' which (they argue) are constructed to preserve a sexual division of labour (1984). Thus, rather than arguing for women's inclusion in work currently defined as skilled and technical, this perspective suggests feminists should be arguing for a total re-evaluation of work so that many of women's traditional tasks are also recognized as skilled and technical and are given appropriate remuneration.

Technology as Culture

More recently, a number of feminists see the newly emerging cultural analyses of technology as a suitable framework for analyzing gender and ICT relationships. This framework understands both technology and gender not as fixed and given, but as cultural processes which (like other cultural processes) are subject to "negotiation, contestation, and, ultimately transformation". There is a fundamental difference between this 'technology as culture' perspective and the many studies of women and technology that talk of the masculine culture of technology and stress ways in which boys and men dominate the design and use of technologies, how the language of technology reflects male priorities and interests, and how women are excluded from full participation in technological work. In the cultural analyses of technology, technologies are 'cultural products', 'objects' or 'processes' which take on meaning when experienced in everyday life. As Henwood says:

> "Our theorizing of the gender and information technology relationship should not be reduced to the simple 'man equals technology literate, women equals technology illiterate' formulation. Technological meanings are not 'given', they are made. Our task trying to transform the gendered relations of technology should not be focused on gaining access to the knowledge as it is but with creating that knowledge. By this I mean to be involved at the level of definition, of making meanings and in creating technological culture".

Henwood and others call for more research from this perspective to understand women's subjective experience and practices of technology and take these as a starting point for definitions of 'technology', 'technological work', and 'skill'.

Democratizing Knowledge and Technology

Adding an important voice for the South to the gender and technology literature, Vandana Shiva argues the inappropriateness of modern western knowledge and technologies for the third world. Underlying her arguments is the view that the North's approach to science and technology has led to western systems of knowledge and technology (based on a particular culture, class and gender) that are now being foisted on the South. Shiva challenges the claim these systems are universal: "emerging from a dominating and colonising culture, modern knowledge systems are themselves colonising". As a result, this 'monoculture of the mind' (or process of technology and knowledge transfer) is displacing local knowledge and experiences. Moreover, "the power by which the dominant knowledge system has subjugated all others makes it exclusive and undemocratic". In opposition to global capitalism, Shiva calls for an alternative, community-based technology and a redefining of knowledge such as that "the local and diverse become legitimate". Thus, the 'democratising of knowledge and technology' perspective is linked to human freedoms because 'it frees knowledge from the dependency on established regimes of thought, making it simultaneously more autonomous and more authentic".

'Subsistence Perspective'

A number of feminists offer new visions of technology and society that are non-exploitative, non-colonial and non-patriarchal. Many of these initiatives draw attention to the need for qualitative changes in the economy and oppose the view that more growth, technology, science and progress will solve the ecological and economic crisis. Maria Mies offers one vision where technology is conceptualized from a perspective of subsistence based on the colonization of women, nature, and other peoples. This 'subsistence perspective' is based on and promotes participatory or grassroots' democracy in political, economic, social and technological decisions. Like eco-feminism, it recognizes that power systems and problems are interconnected and cannot be solved in isolation or by a mere technological fix. This necessarily requires a new paradigm of science, technology and knowledge that allows people to maintain control over their technology. Opposing the prevailing instrumentalist, reductionist science and technology, Mies' new paradigm is based on a multi-dimensional approach that incorporates ecologically sound, traditional, grassroots, women and people-based knowledge systems. As Mies says, "such science and technology will therefore not reinforce unequal social relationships but will be such as to make possible greater social justice". Although some feminists such as Mitter and Rowbotham are not convinced of the practical feasibility of Mies' "critique of modernization", the 'subsistence perspective' shows a conceptual way forward for an alternative vision of gender and technology.

A number of feminists offer new visions of technology and society that are non-exploitative, non-colonial and non-patriarchal.

'From the Experiences of Daily Life'

Other voices from the South welcome modern technologies as long as women can have their say in the manner in which technology is adopted. These women are cautious of the so-called "critics of modernization" who "muffle the appeals and aspirations of many millions of less priveleged women and men, who are 'hungry' for the information revolution and advanced technologies" (Mitter, 1995). They argue that it is difficult for women to shift the balance of power if they are to use only indigenous social and knowledge systems in opposition to modernization and modern technologies. As Mitter says, "women usually have insignificant power over decision-making when they are confined by traditions and constrained by the norms of behaviour in their communities". Third world feminists from this perspective praise the liberating aspects of the information revolution and advanced technologies which, in some circumstances, "gives them economic power, autonomy and the chance to escape the tyrannies of traditional societies" (Mitter and Rowbotham, 1995). In their writings they demand knowledge of and access to technical know-how and business skills, and welcome international exchange of experience of organizing to counteract the pitfalls of the new technologies. As Rowbotham concludes, "a new relation- ship between technology and gender cannot be devised only in the seminar, it has to be created, by users and workers internationally, from the experiences of daily life".

Gender in Communications

In "Women in Grassroots Communications", Pilar Riano maps out women's contribution to the debates on gender in communication beginning with the subordinate position of women in the industry. The recurring themes here point to the lack of women's participation and representation in mainstream media, the sexist portrayal of women in the media, the absence of women in the news and current affairs, and women's disadvantaged access to new communication technologies (International Women's Tribune Centre, 1984; Dervin, 1987; and Moraga & Anzaldua, 1981 as quoted in Riano, p. 30). Early contributions to the gender in communications debates from women in the South, women of colour, and other marginalized groups emerged in the 1960s and 1970s, according to Riano. Their debates focused on the negative portrayal of these women in the mainstream media, demanded equity, and then moved to an emphasis on the qualitative differences these women make in democratizing communications. These collective perspectives suggest that gender identity and the ways women experience subordination are 'connected and mediated' by other variables such as race, class, sexual orientation, age and generation, history, culture and colonialism. Riano points to the creation of coalitions among women in communications as having made the most significant advances. These include women's information networks, women's presses, worldwide networks of independent women filmmakers and video makers, participation of women in journalism schools and mainstream media, and feminists' work in media, cultural and communication studies. These networks create alternative communication channels that articulate other visions of women and act as a form of power that challenges the stereotypical representations of women as passive and silent.

Feminist Communications: Diversity and Complexity

Riano describes a number of principles and concerns that act as a framework to her typology of 'feminist communications' and link to the debate on the 'demoncratization of communications'. Her 'feminist communications' approach is important because it points to the diversity contained in the category 'women' and the complexity of communication strategies and processes. These principles and concerns refer to:

- Women as the main actor of the communication process including women's control over decision making, planning, access to resources, production and distribution.
- Rooting women's communication experiences and ways of communicating in their social and cultural concerns and background.
- Defining communication enterprises as acts of naming and reframing oppressions and as larger movements seeking change.
- Considering grassroots participation as critical to the democratization of communications. This includes a recognition of a variety of communication processes, practices and systems that are distinguished by their grassroots origins (such as women's informal communication practices, networks and associations, or indigenous communication systems and practices), as well as the active involvement of a community or group in using communication to produce their own messages and to engage audiences in critical thinking.
- Identifying women as diverse subjects with different experiences which shape their perceptions and identities—"as subjects of struggles,

as partners of communication, as mothers, as workers, as activists, as citizens".

- These principles and concerns address the broader issues that connect questions of gender and communication with the various ways in which race, class, culture, sexual orientation, age, history, colonialism, and the social division of labour intersect and shape women's communication experiences and identities.

Some Issues and observations

Technology and Democratic Process

The loss of democratic control over technological choice is an important issue for women rooted in the historical debates on the impact of technology on society. It is included here because it relates to the APC's dedication to equalizing the free flow of information. Writing in the late 1960s, Lewis Mumford's "The Myth of the Machine" describes the domination of society by a small, powerful elite who used modern communication technologies to centralize social control. He warns that both individual freedom and community will be submerged by what he calls "the mega-machine" which will "furnish and process an endless quantity of data, in order to expand the role and ensure the domination of the power system". Similarly, in "The Real World of Technology", Ursula Franklin writes about her concerns with the scale of intervention by technologies in every-day life which results in, what she calls, "a culture of compliance" where technology itself becomes an agent of social control. Today, the monopolization of global information and communication structures where government monopolies control a huge share of the world's telecommunication flows, while a few immense corporations dominate the world's mass media, is a very real challenge to women and the democratic process of society.

Increasing Disparities

The many international and national inequalities in existence in the world today is another important issue for women rooted in the historical debates. Increasing disparities as a result of new information technologies relate to the APC's dedication to lessening the gap between the information rich and the information poor. The consensus in the literature suggests there will be an even bigger gap between the information-haves and have-nots in the new electronic era. The facts speak for themselves: "an estimated 95 per cent of all computers are in the developed countries", "10 developed countries, with 20 per cent of the world's populations accounted for almost three-quarters of all telephone lines. The United States had as many telephone lines as all of Asia; the Netherlands, as many as all of Africa; Italy, as many as all of Latin America; Tokyo as many as all of Africa" (Frederick, 1993). Thus, it is particularly important to ensure that women from the South participate in the new communication processes since they are often marginalized because of inadequate infrastructure and the cost of transmitting data.

Democratization of Communications

The 'democratization of communications' is an important issue that appears in the gender and communications literature. It is understood as a process whereby: (a) the individual is an active subject and not only an object of communication, (b) various messages are exchanged democratically, and (c) "the extent and quality of social representation or participation is augmented" (Riano, 1994). The concept was introduced by the MacBride report "Many Voices, One World" where discussions on a new world information and communication order saw democratization being achieved through policy regulation and institutional change at the national and international level. Riano adds, however, that all actors, at all levels (including local and grassroots) need to be considered for an adequate debate on the democratization of communications to be carried out.

Difficulties of Access for Women

The difficulty of access to new information and communication technologies for women is an important issue in the literature. This includes access in terms of sheer hardware and software, as well as requiring access to meaningful resources about women. The fact that most computer networks are currently dominated by men raises further questions about women's access to new information technologies (one study quantifies the male domination of computer networks at 95 per cent) (WITS, p. 17). In "Nattering on the Net", Dale Spender notes that women's marginalization from the new communication technologies is "less to do with women and more to do with computers" arguing that computers are the site of wealth, power and influence. She warns that women cannot afford "to permit white male dominance of these technologies because a very distorted view of the world is created when only one social group, with one set of experiences pronounces on how it will be for all". Relevant and useful resources about women will not appear unless women work to create them (often under difficult situations) and, since women's knowledge is presently encoded in books, women's knowledge may be endangered if the shift from the print to electronic medium is not made. Currently, there are few women in positions of leadership

making the decisions about what electronic materials will be constructed and what they will contain. Women's task, according to Maureen Ebben and Cheris Kramarae is "to create, electronically, a cyberspace of our own that fosters women's communication in this time of rapid technological transition" (1993, p. 16).

Currently, there are few women in positions of leadership making the decisions about what electronic materials will be constructed and what they will contain.

Failure of Training Programmes

Another important observation found in the literature is the shortcoming of mainstream training methods for women. Most authors contend that the problem is not so much a problem of how to teach women effectively, but that "training is ad hoc, unsystematic, and male-centered" (Ebben and Kramarae, p. 18). In a recent WITS study, the researchers give the example of training offered at computer sites at universities as an illustration of this kind of training. The training consisted of "directions posted on walls, photocopied sections of published manuals left in strategic places, or an hour's worth of group instruction in which participants are led through a manual's directives". They concluded that the instruction is seldom customized and there is little opportunity to follow-up on questions and problems that arise during actual use.

Other commentators suggest that the lack of training is a more severe problem for women than for men because of the culture of technology which "shares an image of machismo and valorizes the adventurer" (Hacker, 1989, 1990 and Turkle 1984, 1988). The difficulty for women is explained in most part because women and men tend toward different learning styles. Studies (Turkle and Papert, 1990) suggest that many women prefer to learn through an orderly routine in which they understand the reason for each step, whereas many men (and boys) have been encouraged to learn through experimentation and trial and error. In addition, women take fewer risks than men do and men prefer to tinker around the new environment. This coupled with male-style and unsystematic learning practices, puts women at a disadvantage.

Women Working in Technology

Mitter's and Rowbotham's anthology "Women Encounter Technology" explores the impact of technology on women's employment and the nature of women's work in third world countries. Their observations provide an "authentic international perspective" on women and technology that can inform further research. Some observations that are particularly relevant to the APC Women's Programme's study include:

- Gender is one of many factors that determine the impact of information technology on women's working lives. Ethnicity, religion, age and class can play even greater roles in defining women's working position. Similarly, the degrees of exclusivity that arise from the information revolution sharply differentiate regions and communities.
- Technological changes affect the quality and quantity of women's work. Along with women's employment benefits from new technologies there are associated health, environmental and other costs. Employment issues of concern to women working in technology relate to contractual terms, intensification of workloads, wages, training, and health and safety such as VDU hazards and repetitive strain injuries.
- Increased job opportunities bring new tensions in women's domestic lives. For example, Acero's case study documents the typical life of a woman textile worker in Argentina: "My marriage started to break down when I started to work... I had more chances than he did. So things started to go wrong". Deeper insights are needed into the links between women's status and the role at work and at home.
- Women are rarely represented in the decision-making areas of technology. As a number of essays document, women are pre-dominantly only in blue-collar jobs. In the next phase of the technological change these are precisely the jobs that will be vulnerable.
- Upgrading women's skills through a continuous learning process benefits women and society.
- Radical thinking about training is essential for utilizing women's potential. In particular, training needs to take into account ethnicity, class, religion and age.
- Women's sharing of experiences has proved rewarding at the community, national and international level. More international exchanges of experience in organizing around some of the new issues relating to the electronic era are needed in order to ensure that women's employment benefits from new technologies

are not outweighed by the associated health and environmental costs.

References

Allen, Donna, Ramona R. Rush and Susan J. Kaufman (Eds.) (1996), "Women Transforming communications—Global Intersections", London: Sage.

Derkin, B. (1987), "The potential contribution of feminist scholarship to the field of communication", in Journal of Communication, 37(4), 107-120.

Ebben, Maureen and Cheris Kramarae (1993), "Women in Information Technologies: Creating a Cyberspace of Our Own", in H. Jeanie Taylor, Cheris Kramarae, and Maureen Ebben (Eds). Women, Information Technology and Scholarship. Urbana, Illinois: Women, Information Technology and Scholarship Colloquim, Centre for Advanced Study.

Franklin, Ursula (1990), "The Real World of Technology". Toronto: CBC Enterprises.

Frederick, H. (1993) in Linda M. Harasim (Ed.), "Global Networks: Computers and International Communication", Cambridge, MA: MIT.

Game, A. and R. Pringle (1984), "Gender at Work", London Pluto Press.

Hacker, Sally (1990), "Doing it the Hard Way: Investigations of Gender and Technology", Boston: Unwin Hyman.

Henwood, Flis (1993), "Establishing Gender Perspectives on Information Technology: Problems, Issues and Opportunities", in Eileen Green, Jenny Owen and Den Pain (Eds.) Gendered Design? Information Technology and Office Systems. London: Taylor & Francis.

International Women's Tribune Centre (1984), "Women Using Media for Social Change", New York: IWTC.

Mies, Maria and Vandana Shiva (1993), "Ecofeminism", London: Zed Books.

Mies, Maria (1986), "Patriarchy and Accumulation on a World Scale—Women in the International Division of Labour", London: Zed Books.

Mitter, Swasti and Sheila Rowbotham (Eds.) (1995), "Women Encounter Technology: Changing Pattern of Employment in the Third World", London and New York: Routledge.

Moranga, C. and G. Anzaldua (Eds.) (1981), "This Bridge Called My Back: Writings by Radical Women of Color", Matertown, MA: Persephone Phone.

Mumford, Lewis (1967 and 1970), "The Myth of the Machine", New York: Harcourt Brace Jovanovich.

Shiva, Vandana (1993), "Monocultures of the Mind", London and Penang: Zed Books and Third World Network.

Shiva, Vandana (1997), "Biopiracy—The Plunder of Nature and Knowledge", Toronto: Between the Lines.

Spender, Dale (1995), "Nattering on the Net—Women, Power and Cyberspace", North Melbourne, Australia: Garmond Press.

Turkle, Sherry (1984), "The Second Self: Computers and the Human Spirit", New York: Simon and Schuster.

Turkle Sherry (1988), "Computational Relicence: Why Women Fear the Intimate Machine", in Cheris Kramarae (Ed.), Technology and Women's Voices: Keeping in Touch, New York: Routledge.

Turkle, Sherry and Seymour Papert (1990), "Espistemological Pluralism: Styles and Voices Within the Computer Culture", in Signs: Journal of Women in Culture and Society 16(1), 128-157.

Riano, Pilar (Ed.) (1994), "Women in Grassroots Communications: Furthering Social Change", London: Sage.

Wajcman, Judy (1991), "Feminism Confronts Technology", London: Polity Press.

□

Without the vision of a goal, a man cannot manage his own life, much less the lives of others.

– Genghis Khan

Feature

Effectivity of Knowledge Transfer Through Expatriate Professionals

M.K.D. Rao & S.C. Rastogi

This paper analyses the performance of consultants in Transfer of Knowledge through Expatriate Nationals (TOKTEN) Programme for the period 1985-93 in one of the sub-fields, namely, electrical, electronics and computer engineering through 'per-day' weighted impact. This paper analyses the affect of specialisation, affiliation, experience, age etc. of the NRI consultants on the outcome of consultancy.

M.K.D. Rao is scientist and S.C. Rastogi is ex-scientist, Council of Scientific & Industrial Research, Pusa, New Delhi.

The 'Transfer of Knowledge through Expatriate Nationals' (TOKTEN) is a UNDP-Government of India project initiated in developing countries for the advancement of science and technology. This programme was first started in Turkey in 1976 [Morota, 1998]. TOKTEN-India was initiated in March, 1980. India was the fifth nation to adopt TOKTEN. The UNDP was the funding agency of the programme and the Council of Scientific & Industrial Research (CSIR) was the implementing agency at the national level on behalf of Govt of India. Under this programme, the expatriate scientist/technologist working in frontier areas of knowledge is given an opportunity to contribute to the development of science and technology in the motherland.

The initial formative period, 1980-1984, was spent on propping up the support systems and procedures including the establishment of database on potential TOKTEN consultants and the host organisations. The period 1985 to 1990 is characterised by creating linkages with user organisations in India and with Governmental departments, industrial associations and change of gear from initial 'supply push' of consultants to 'demand pull' by the hosts/users together with further strengthening of database. The years 1991 to 1994 may be seen as a movement to align the TOKTEN objectives with the national development priorities, with an increasing focus on industrial applications and newly emerging fields. From 1995, efforts to reform TOKTEN were initiated culminating in the incarnation of the 'Umbrella Project' with the amalgamation of the Technical Cooperation among Developing Countries (TCDC) and the United Nations International Short-term Advisory Resource (UNISTAR). The Umbrella Project came to an end in June 2001.

The TOKTEN experts have served research and development (R&D) institutions, public and private sector enterprises, universities and other organizations in fields ranging from agriculture, engineering and sciences to computer technology and management. TOK-

TEN has been able to cover a wide spectrum of disciplines such as alternative power resources, architecture, biotechnology, industrial hygiene and safety, machine and tool designing, microelectronics, polymer chemistry, remote sensing, telecommunications and management of water resources. The assistance rendered by the consultants included suggestions on new approach, improvement in existing processes, designing of curriculum, demonstration of new techniques, holding discussions, delivering lectures in seminars and workshops [CSIR, 1994]. Additionally, there have been valuable benefits in the form of spin-offs such as advanced level training of scientists and researchers in the institutions of the consultants abroad without any cost to the exchequer, the financial implications of which could run into several crores of rupees. Also the donations made by a large number of consultants by way of chemicals, software, and scientific tools for research offered to various host organisations, are very significant.

The TOKTEN was reviewed thrice on different occasions by three different evaluation missions of UNDP. The reports provide an array of analysis of consultancies evolved sector-wise, agency-wise, discipline-wise, by host and by institutional affiliation, specialisation, experience, year, duration, country of origin, purpose, age group of consultants etc. However, they do not attempt to measure the impact of consultancies. This paper tries to measure the effectiveness of contribution of TOKTEN experts. The approach adopted was to categorise the contributions, as indicated above, and then assign them appropriate weight. The method facilitated to quantify the magnitude of the contribution made by the consultants to the host/user organisations. The performance of the consultants is determined through the 'per-day' weighted contributions. Our method is comparable to the 'BETA method', an attempt made in France to calculate the economic effects of programmes upon participating organizations. In this method, managers in organizations were interviewed to identify added value for sales and cost savings and attribute a portion of this to their participation in the project. However, this was precisely the difficulty faced by the managers as in many cases the saving could not be clearly linked to just one project. In the present 'per-day contribution' method, the feedback reports were first studied and contributions were then distributed among the available categories.

The inferences drawn in the study are based on information pertaining to one of the sub-fields, namely, electrical, electronics and computer engineering. The source of information is the technical reports submitted by the consultants on completion of their assignment. In all, there were 412 consultants who had visited India under the TOKTEN-India project during 1985-93. Engineering and technology was the area of specialisation of most of the TOKTEN consultants (47%), out of which most of consultants were from the sub-field of electrical, electronics and computer engineering (31%).

The technical reports available for the present study were those submitted by 59 out of the 65 consultants who visited India under the project. Based on the available reports, there were 176 consultancies made in 1307 days. Thus, the present study is based on 90% technical reports for the above group and 32% of total consultants visited under this area in TOKTEN-India project for the period 1985-93.

The objective of the analysis is to quantify the contributions made by TOKTEN consultants during their assignments in India. The purpose is to determine:

- estimated financial value of the consultancies rendered
- year when the consultants contributed maximum
- type of benefit that accrued most to host organisations
- field in which the consultants contributed the maximum, within the sample area.
- impact of experience, age of consultants on the benefits accrued
- optimal duration of visit of consultant in the sample

However, it is pointed out that no comparative study has been done due to non-availability of required data for comparison.

Methodology

The feedback reports submitted by the consultants was studied to cull out information pertaining to their contributions during that period and place them under the identified category (ies) such as new approach suggested, demonstration of new technique. Weights were then assigned according to the category. Per-day weighted contribution was then computed for quantification, which facilitated the study of the magnitude of the contributions of experts related to year, specialisation, experience, age, organisation etc.

The different categories of 'contributions' and their 'weights' considered for the study are presented in Table 1.

Table 1: Model weights for the contribution of consultants

Category	Contribution	Category weight	Sub-category weights	Model weight*
A	Extraordinary work done	200	200	15.38
B	New approach suggested	100	100	7.69
	Improvement in existing processes		90	6.92
	Laboratory procedure demonstrated/developed		80	6.15
C	Collaborative project initiated for new process	75	75	5.77
	Collaborative project initiated for new product		70	5.38
	Samples taken from India by the NRIs for testing/ analysis in their laboratory		55	4.23
D	Information dissemination	50		
	Workshops		50	3.85
	Seminars		35	2.69
	Courses		45	3.46
E	Information dissemination	15		
	Lectures		13	1.00
	Discussions		15	1.15
F	Provision of Research Aids (Chemicals iterature, software etc.)	30	30	2.30
G	Interactions	1	1	0.08

* Model weights are computed assuming the weight for the contribution of a lecture as 1. For example, 200/13 = 15.38

b) A TOKTEN consultancy is defined as visit of an expert to a host organisation.

c) The cost of a lecture delivered by the TOKTEN expert is considered equivalent to US $ 300. The cost in Indian currency is about Rs.10,000, @ Rs. 33/- per US dollar, the then prevailing rate.

Contribution of Consultants

It is observed from the data that the consultants have significantly contributed towards the improvement in existing processes from 1985 to 1993. Further, the collaborative projects initiated for new processes and the provision of research aids shot up in 1993 when compared to previous years.

The contribution towards the computer science/engineering is the highest (Table 2). However, improvement in existing processes and laboratory procedures demonstrated/developed are higher in case of electronics. It is observed that the contributions in respect of all the categories mentioned in Table 1, are significantly higher for the consultants affiliated to academic institutions.

Table 2: Contributions by field of specialisation

Category		Computer	Electrical	Electronics	Telecommunication
1.	Extraordinary work done	2	9	4	-
2.	New approach suggested	4	1	5	0
3.	Improvement in existing process	7	1	12	1
4.	Lab. procedure demon-strated/-developed	0	0	5	0
5.	Collaborative project initiated for new process	10	2	4	0
6.	Collaborative project initiated for new product	0	0	4	0
7.	Samples taken from India by the NRIs for testing and analysis in their laboratory	1	1	3	0
	Information dissemination through				
8.	Workshops	5	14	0	1
9.	Seminars	25	30	35	15
10.	Courses	3	5	1	0
Information dissemination through					
11.	Lectures	132	42	54	10
12.	Discussions	78	79	102	6
13.	Provision of research aids (chemicals/ literature /software etc.)	7	3	19	3
14.	Interaction	176	105	134	9

Table 3: Distribution of working days by fields of specialization

Host Organisation		Field of specialisation				
		Computer sc/engg.	Electrical engg.	Electronics engg.	Telecom.	Total
1.	CSIR	124	12	128	12	276
2.	Other R&D	84	106	59	4	253
3.	Industry	142	74	51	36	303
4.	Academic institutions	101	110	167	11	389
5.	Govt.Tech Deptt.	56	13	17	0	86
	Total	507	315	422	63	1307

The contribution of consultants to CSIR laboratories as the host organisations, is good particularly in (i) improvement of existing processes and (ii) collaborative projects initiated for new processes as compared to other R&D institutions, academic institutions and industries. Further, consultants with more than 20 years experience have suggested more new approaches and improvements in existing processes. Extraordinary work was performed by the consultants with higher experience. Consultants in the 41-45 years age group had contributed more than those in other age groups.

TOKTEN India Programme was spread over 1307 working days for Engineering and Technology - I during the period 1985-95. These had been utilised for conducting a number of activities in science and technology. For various host organisations groups, the distribution of the working days is presented in Table 9 for the period 1985 - 95. It is observed that the maximum working days of the consultants are in 1991. Over the period 1985 to 1993, the utilization of the project by academic institutions was the maximum, sharing 30% of the total working days followed by industries (23%).

It may be seen from Table 3 that about 45% of the working days in CSIR were utilised by each of the two fields namely computer science/engineering and electronics. Computer science/engineering had a maximum share of 47% of the working days utilised in industries.

Per-day Weighted Contribution and Economics of Contributions

Table 4: Year-wise per-day weighted contribution and its economics

(Rs. million)

Year	Weighted contribution		Contribution economics	
	Total	Per-day	Total	% Share
1985	22.7	0.65	0.227	1.37
1986	236.1	1.37	2.361	14.22
1987	275.1	1.08	2.751	16.57
1988	103.1	1.10	1.031	6.21
1989	166.6	1.19	1.666	10.04
1990	64.4	1.00	0.644	3.88
1991	360.7	1.35	3.607	21.73
1992	159.6	1.26	1.596	9.62
1993	271.5	1.83	2.715	16.36

Weighted contribution was computed from the category-wise weights assigned in Table 1. The gross weighted contributions of TOKTEN consultants in the sub-field electrical, electronics & computer engineering is 1659.8 units during 1985-93 (see Table 12). The weighted contributions are further analysed as follows.

Table 5: Per-day weighted contribution by field of specialization and its economics

Rs. in million

Field of specialisation	Weighted contribution		Contribution economics	
	Total	Per-day	Total	% Share
Computer sc./engg.	520.7	1.03	5.207	31.4
Electrical engg.	468.9	1.50	4.689	28.3
Electronics	594.6	1.40	5.946	35.8
Telecommunication	75.7	1.20	0.757	4.5

Table 6: Per-day weighted contribution by host organisations and its economics

(Rs. million)

Group of Host organisations	Weighted contribution		Contribution economics	
	Total	Per Day	Total	% Share
CSIR	324.1	1.17	3.241	19.5
Other R&D	395.1	1.56	3.951	23.8
Industry	355.0	1.17	3.550	21.4
Academic institute	433.0	1.11	4.331	26.1
Government Technical Department/Organisation	152.6	1.77	1.526	9.2

Table 7: Experience-wise per-day weighted contribution

Experience	Weighted contribution	
	Total	Per-day
below 10	294.1	1.18
11 - 15	406.5	1.01
16 - 20	324.5	1.18
above 20	634.7	1.67

Table 8: Per-day weighted contribution by age

Age	Weighted contribution	
	Total	Per-day
upto 35	96.9	1.18
36 - 40	292.2	1.03
41 - 45	502.4	1.30
46 - 50	329.3	1.41
51 - 55	215.4	1.49
above 55	223.6	1.27

Table 9: Per-day weighted contribution by expert's institutional affiliation

Institutional affiliation	Weighted contribution		Consultancy		
	Total	Per-day	Industry	Total	% Share
Academic institute	1159.2	1.31	20	97	20.6
Industry	411.0	1.13	17	62	27.4
R&D	89.6	1.49	7	17	41.2

The year-wise per-day weighted contributions have been computed and are given in Table 4 for the period 1985 to 1993. It may be observed that in 1991, the maximum weighted contribution was 21.7% of the gross weighted contribution. Per-day weighted contribution from the consultants was observed to be significantly higher in 1993 indicating higher degree of effectiveness in the utility of expertise in that year. Further, there is a wide variation in the annual economics of the contributions varying from Rs 0.227 million to Rs 3.607 million during 1985-1993.

The weighted contribution as per the field of specialisation and its economics is shown in Table 5.While the impact of TOKTEN consultancy in the field of electrical engineering is estimated to be the highest at 1.50, the contribution economics of the TOKTEN consultants in the electronics field is estimated to be about Rs.0.6 million, the largest.

Per-day weighted contribution is observed to be maximum for the government organisations like the Indian Telephone Industries, Central Electronics Ltd, Indian School of Mines, Survey of India, Traffic & Transportation Planning Directorate, Department of Electronics; even though the total is not the highest (Table 6). This may be attributed to the matching of assignment with the host organisation and the Indian partners with whom they interacted and also the institutional arrangements in these organisations. Moreover, the contribution from consultants deputed to academic institutions is estimated to be Rs. 4.33 million.

Experience-wise weighted contribution of the consultants is given in Table 7. The weighted contribution of consultants having more than 20 years experience is more as compared to those possessing less experience.

The age-wise weighted contributions by the consultants in Table 8 suggests that most productive age group is 51-55 years.

The weighted contribution for institutional affiliation of various consultants is presented in Table 9. It may be seen that the consultants affiliated to academic institutions had contributed around 70% of the gross contribution.

On the basis of the assumptions made in Section 4, the benefits accrued from the visits of TOKTEN consultants is estimated to be Rs.16.6 million during 1985-93 in the sub-field of electrical, electronics and computer engineering.

The per-day weighted contribution by duration of visit is given in Table 10. It shows that up to 5 days of visit to a host organisation was optimal for best contributions. However this feedback should not be seen as sacrosanct as duration depends on other prime factors like the nature of assignment, the capacity of recipient, the expertise of consultant etc.

Impact on Industrial sector

The techno-economic development of a country depends on the vibrancy and competitiveness of its industries. Application of appropriate technologies with regard to processes, products, raw materials etc helps to optimize the resources and minimises wastage. A joint evaluation mission on TOKTEN has reported that a few of them have provided direct benefits to R&D efforts by introducing approaches that reduce production costs and sustain product quality [United Nations Development Programme, 1994]. TOKTEN consultants had provided a total of 176 consultancies in different host organisations in the country during the period 1985-93. Out of these, 44 consultancies were in the industrial sector.

It is observed that the number of TOKTEN consultancies to industries varies from 3 to 11 consultancies over the years. However, during 1990 and 1992 no expert was fielded to the industries.

The consultancies in industries were examined according to the fields of specialization. The consultancy in telecommunication stood at the highest (33%) and in electronics the lowest (17%).

As per affiliation of consultants, TOKTEN consultants from the industry were utilised for consultancy in the Indian industries which was 27.4% (Table 9). Consultants from R&D organisations provided about 41.2% consultancies to the industries.

Weighted contribution made by TOKTEN consultants in industry alone was approximately 355 units. This

contribution was about 21.4% of the total contribution made by the consultants who had visited the country during the period 1985-93 in the sub-field of electrical, electronics & computer engineering.

It may be seen in Table 11 that the TOKTEN contribution to the industries was satisfactory during 1985-88 as the same is above 33%. Beyond this the contribution in industry is less than 16%.

Per-day weighted contribution in the industrial sector for various fields of specialisations is in Table 12. It emerges from this table that the percentage share of Computer Science/Engineering is about 45% of the contribution made by the TOKTEN consultants in the industries. The per-day weighted contribution in electrical engineering was 1.44. This indicates that the organisations in these areas were more receptive as compared to organisations in other fields.

Per-day weighted contribution in industry for consultants in different experience groups was studied. Consultants having 11-15 years experience share 43% of total industrial contribution, which is the maximum among all the age groups. Consultants with more than 20 years experience contribute about 50% more as compared to younger ones.

Consultants in the 41-45 years age group contributed about 39% of the total weighted contribution in the industries. But the contribution of consultants in the age group 51-55 contributed the most, when seen on per-day basis.

Outcome of analysis

The following are the main inferences drawn from the analysis:

(A) TOKTEN Consultants

- On a cumulative basis, 15.8% of the consultants visits under TOKTEN programme during the period 1985-93 are in the sub-field of electrical, electronics and computer engineering.
- in terms of affiliation, 63% consultants belonged to academic institutions and about 32% were from industry.
- about 70% consultants had 3-6 weeks visit duration in an host organisation.
- 82% consultants had experience of more than 10 years.

(B) Consultancy

- about 34% consultancies were rendered in electronics, which was the maximum.
- maximum consultancies were provided by consultants in the age group 41-45 years.
- more than 50% consultancies were up to a duration of one week.

(C) Contribution of Consultants

- the trend of annual contribution of TOKTEN consultants is in increasing order.
- the preparedness of host organisations improved, in general, to get maximum benefit from the TOKTEN programme.
- per-day contribution of TOKTEN consultants is highest in electrical egineering.
- Govt organisations appear more attentive towards the utilisation of TOKTEN consultants services.
- consultants possessing experience of over 20 years were found more attentive towards the problems of the host organisations.
- although maximum consultants were from academic institutions, those affiliated to R&D organisation contributed the maximum on a per-day basis.
- there is negative correlation between the duration of visit and the contribution of consultants.

(D) Contribution Economics

- contribution of TOKTEN consultants was around Rs. 16.7 million.
- contribution of consultants was maximum in 1991 (Rs. 3.6 million).
- contribution of electronics engineering organisations as the host was about Rs 6 million.
- contribution of consultants was maximum (Rs. 4.3 million) in academic institutions.

(E) Industrial Sector

- about 25% of the total consultancies are in the industrial sector.
- 38% of the consultancies in the industrial sector are from those consultants affiliated to industries.

Table 10: Per-day weighted contribution of consultants by duration of visits

Duration of visit (Days)	Weighted contribution	
	Total	Per-day
upto 5	499.2	1.72
6 - 10	476.5	1.31
11 - 15	290.3	1.22
16 - 20	211.8	1.10
21 - 25	58.7	0.85
26 - 30	38.7	0.77
above 30	84.7	0.89

Table 11: Year-wise weighted contribution in Industry

Year	Total Weighted contribution	Industrial Total	Weighted contribution	
			% Share	Per-day
1985	22.7	14.2	62.6	0.65
1986	236.1	78.3	33.2	1.70
1987	275.1	91.5	33.3	1.09
1988	103.1	50.0	48.5	1.02
1989	166.6	24.4	14.6	1.32
1990	64.4	0.0	0.0	0.00
1991	360.7	53.7	14.9	1.28
1992	159.6	0.0	0.0	0.00
1993	271.5	42.9	15.8	1.07
Total	1659.8	355.0	21.4	1.17

- contribution of consultants in the industrial sector is in decreasing order.
- maximum weighted contribution from TOKTEN consultants was in computer science/engineering industries.
- maximum attention of host organisation was received by the consultants in electrical engineering industries.

Table 12: Per-day weighted contribution in industries by field of specialisation

Field of specialisation	Weighted contribution	
	Total	Per-day
Computer Science/Engineering	160.5	1.13
Electrical Engineering	106.4	1.44
Electronics	54.4	1.07
Telecommunications	33.7	0.94

References

Council of Scientific and Industrial Research; "TOKTEN-India Programme: Terminal Review Report", August 1994.

Morota, Ikuko March (1998), "Desk Review on the TOKTEN", (Unpublished).

United Nations Development Programme; "An in-depth evaluation of the TOKTEN-India project 1980-1990" by A.K. Sharma, B.C. Tandon and A. B. Bhattacharya, pp. 33, Appendices pp. 67, October 1990.

United Nations Development Programme, "Report of the Joint Evaluation Mission" by Jean Raymunde Lobell and Radha Maheshwari, pp 75, Appendices pp 16, June 1994. □

One must be frank to be relevant.

– Coraon Aquino

Feature

Constraints in Work Environment – An Empirical Study of Research Groups in India and China

Anju Chawla

A central issue in the management of research institutions is to identify and remove the constraints faced by scientists in their work environment. This paper seeks to assess the relative importance of 49 potential constraints relating to human and material resources, management ethos and the social-psychological climate for research, as perceived by scientists in India and China.

Anju Chawla is faculty at the National Institute of Science, New Delhi.

Scientific research, like any other social endeavour, requires inputs of resources. An issue of central concern is how do we define resources? *Stolte-Heiskanen* (1979) has proposed a typology for classification of different types of resources required for research and development. According to this typology, the various resources can be classified into two categories – externally determined resources and internally determined resources. Externally determined resources are physical and material, whereas internally determined resources are organisational and behavioural in nature. Externally determined resources are no doubt necessary, but not a sufficient condition for R & D performance (*Andrews*, 1979; *Nagpaul and Chawla*, 1995). *Chawla* and *Singh* (1998) have constructed a typology of research units according to a set of organisational features and related the resulting classification to a set of performance measures. Their study shows that good management can fairly counterbalance a certain shortage of physical resources, but that performance is poor when both resources and management are poor. The highest performance is achieved when both physical and management resources are good.

An important concern of science policy is to improve the performance and productivity of research institutions in the country. It therefore enjoins upon the management of research institutions to identify and remove the constraints faced by scientists in their work environment. This paper responds to these concerns and seeks to assess the relative importance of different types of constraints perceived by the scientists in India and China.

Methodology

The Data

As a result of extensive literature survey and feed-

back from the first three rounds of the International Comparative Study on Organisation and Performance of Research Units (ICSOPRU), a set of 49 factors were identified, which were considered as potential constraints on research and development activity. These were classified into four categories:

1. Human resources for research and development work (9 items tapping the quantity and quality of scientists and technicians, recruitment and turnover)
2. Scientific and technical facilities (12 items tapping quantity and quality of equipment and facilities, information services and databases)
3. Working conditions for research (14 items tapping cooperation, communication, human relations and ecology of the workplace)
4. Financing and management of research (14 items tapping leadership, financing and management of research)

These factors are listed category-wise in Tables 2-5.

Since the objective of the study was to assess the relative importance of various constraints, the ranking approach was used because of its simplicity (*Eckenrode* 1969). However, a major drawback of complete ranking is that its accuracy decreases with the increase in the number of items to be ranked. According to *Nijkamp* and *Voogd* (1965), respondents are able to discriminate optimally between a maximum of seven items. The more items being used, the less appropriate it would be to perform a complete ranking. Hence, the questionnaire was designed in the format of *Partial Ranking*.

In this format, the respondents were asked to select within each group:

- *Firstly:* a subset of four factors, which had been at the root of the most significant difficulties in their research work.
- *Secondly:* Rank the selected factors in order of decreasing importance
- *Finally,* the respondents were asked to select a subset of six factors, ignoring the grouping introduced in the questionnaire which they felt had created the most significant difficulties in their research work, and then rank the selected factors in order of decreasing importance.

This paper is based on two datasets: (i) Data collected in China for the fourth round of ICSOPRU, and (ii) Data collected in India using an identical instrument.

Analytical procedure

A major technical problem in analyzing preference or ranking data is how to aggregate individual responses and compute an overall ranking of different factors. Commercial software, such as SPSS, STATISTICA, or SYSTAT does not include any procedure for aggregation of preference data. Hence, we have used a fuzzy ranking method implemented in IDAMS software, developed by UNESCO. The method is based on *Orlovsky's* (1978) algorithm, originally proposed for solving decision-making problems with fuzzy information, and subsequently modified by *Hunya* (*Dussaix*, 1984) to adapt to the problems in which alternatives have to be ranked on the basis of collective opinion. This adaptation makes it possible to find a sequence of non-dominated layers (or cores) of alternatives in a fuzzy preference structure, which does not necessarily represent a total linear order. The subsequent cores are groups of alternatives, which have the highest rank among the alternatives that do not belong to previous higher level cores. Obviously, the first core comprises alternatives that have the highest rank. In this procedure, it is quite possible that more than one alternative may belong to the same core, *i.e.,* receive the same rank.

The algorithm first computes a matrix of fuzzy relations among the set of alternatives, from which it computes an overall ranking of alternatives and a set of indices to indicate the degree of consensus among the respondents—*Absolute Coherence, Intensity Index* and *Absolute Dominance.*

- *Absolute coherence (Ca)* is an indicator of unanimity in the preference data.

$$C_a = \frac{\sum_{k<l} |r_{kl} - r_{lk}|}{\sum_{k<l} (r_{kl} + r_{lk})}$$

$Ca = 1$ implies full coherence and $Ca = 0$ implies full lack of coherence

- *Intensity Index* is defined by the expression:

This index can be interpreted as average credibility level of the statements "a_k is preferred to a_t" or "a_t is preferred to ak".

$$I = \frac{\sum_{k<l} |r_{kl} + r_{lk}|}{n(n-1)/2}$$

Table 1: Input Relational Matrix

A1	A2	A3	A4	A5	A6	A7	A8	A9	
A1	0.0000	0.5169	0.3390	0.5169	0.5085	0.5254	0.5339	0.4576	0.5424
A2	0.1271	0.0000	0.1864	0.2458	0.2203	0.2458	0.2542	0.2288	0.2542
A3	0.5254	0.6356	0.0000	0.6610	0.5932	0.6525	0.6864	0.5763	0.6864
A4	0.1102	0.1441	0.1186	0.0000	0.1186	0.1610	0.1525	0.1186	0.1525
A5	0.2119	0.3475	0.2373	0.3220	0.0000	0.2881	0.3559	0.2373	0.3475
A6	0.017	0.1525	0.1102	0.1780	0.1780	0.0000	0.1864	0.1610	0.1864
A7	0.1356	0.1610	0.0847	0.1780	0.1271	0.1610	0.0000	0.1102	0.1780
A8	0.4153	0.5508	0.3305	0.6186	0.5593	0.6186	0.6102	0.0000	0.6356
A9	0.1017	0.1017	0.0763	0.1102	0.1017	0.1102	0.1271	0.1017	0.0000

- *Absolute dominance* is defined: by the expression:

$$D_a = \frac{\sum_{k<l} |r_{kl} - r_{lk}|}{n\,(n-1)/2}$$

This index can be interpreted as the average difference between the credibility of the preposition "a_k is preferred to a" and the opposite preposition "a is preferred to a_k".

Analysis and Results

Factors relating to human resources

Table 1 shows the matrix of fuzzy relations among the set of alternatives for the Indian data. The cells of this matrix indicate the dominance of one alternative over another. For example, the cell (Column 1, Row 3) indicates that the dominance of Alternative A_1 over Alternative A_3 is 0.5254, whereas the dominance of Alternative A_2 over Alternative A_1 is 0.3390. This implies A_1 was preferred less than Alternative A_3. It should be noted that the sum of these two dominances is less than 1. This is because some of the respondents did not choose alternatives A_1 or A_3.

In this matrix the values of only 20 cells (boldface type) out of 72 valid cells exceed the threshold of simple majority, which means that 27.8 per cent preferences were expressed in a very clear manner. This figure does not seem to be low, when we take into account the small number of alternatives cited (4 out of 9). This is confirmed by the index of cohesion, 0.6802, which indicates quite good consensus, among the respondents.

In the case of Chinese data, the values of 13 cells exceeded the threshold of simple majority, which means that only 18 per cent preferences were expressed in a very clear manner. The values of absolute coherence and absolute dominance are higher for India than those for China, which implies greater consensus among Indian scientists about the relative importance of different constraints than among their counterparts in China.

The ranking of different factors for India and China may be visualized from Table 2, which is self-explanatory.

Table 2: Factors relating to human resources of the project

Rank	India	China
1	Inadequate professional background of technician vis-à-vis the demands of the research work assigned	Insufficient number of qualified scientist/engineers in the project.
2	Inadequate professional background of scientists or engineers with respect to the research work assigned	Inadequate professional background of scientists or engineers vis-à-vis the demands of the research work assigned
3	Delays in staff recruitment	Insufficient number of qualified technicians working in the project
4	Insufficient turnover of technicians	Delays in staff recruitment
5	Insufficient number of qualified scientists or engineers in the project.	Inadequate professional background of technicians vis-à-vis the demands of the research work assigned
6	Insufficient turnover of scientists or engineers	Insufficient turnover of scientists or engineers
7	Insufficient number of qualified technicians working in the project.	Excessive turnover of scientists or engineers
8	Excessive turnover of scientists or engineers	Insufficient turnover of technicians
9	Excessive turnover of technicians	Excessive turnover of technicians
	Absolute coherence = 0.6802	Absolute coherence = 0.4828
	Intensity = 0.6029	Intensity = 0.5385
	Absolute dominance = 0.3830	Absolute dominance = 0.2600

An interesting observation is that in spite of differences in political and socio-cultural settings in India and China, constraints relating to human resources are about the same, though not identical. *Bureaucratic delays* in recruitment of staff are the third most important factor in India, whereas it occupies the fourth rank in China. *Inadequate professional competence* of scientists vis-à-vis the demands of the research work assigned to them is the second most important factor in both countries. But there are also important differences:

- Shortage of qualified scientists and engineers is the most important constraint in China, but not in India, where it is relegated to the fifth rank.
- Inadequate professional competence of technicians is the most important constraint in India but not in China, where it is relegated to the fifth rank. Coupled with inbreeding, due to insufficient turnover of technicians and delays in recruitment, it essentially implies that qualified scientists and engineers in India have to spend time on those activities which could be done by technicians. This under-utilization of scientists is aggravated by the time spent on scientifically unproductive tasks, which occupies the first rank in the list of constraints relating to working environment for research (Table 4). In China, this factor is relegated to the sixth rank.
- China seems to face a shortage of scientists, both in terms of quantity and professional competence, and to a lesser extent that of technicians. China has attempted to mitigate the consequences of these problems by freeing the scientists from involvement in unproductive tasks and avoiding the spread of resources on too many projects.

Factors relating to scientific and technical facilities

The matrix of fuzzy relations among different alternatives indicated that only 5.5 per cent of cell exceed the threshold of simple majority in the Indian data, whereas none of the cells exceed this threshold. Indian scientists have expressed their preferences somewhat more clearly than their counterparts in China. These figures are low, but not alarming since the respondents had to choose only four out of 12 alternatives. The values of absolute cohesion and absolute dominance are somewhat lower for India than for China, implying greater cohesion in ranking of alternatives among the Chinese respondents than among the Indian respondents. The value of intensity is higher for India compared to China (Table 3).

Table 3: Factors relating to scientific and technical facilities

Rank	India	China
1	Difficulty of access to S&T computerized databases	Inadequacy of specialized scientific equipment
2	Inadequate maintenance and repairs services	Delays in obtaining scientific equipment
3	Inadequate computerized data processing services	Inadequate information services
4	Inadequacy of specialized scientific equipment	Poor quality of specialized scientific equipment
5	Poor quality of specialized scientific equipment	• Poor quality of ordinary scientific equipment • Inadequate technical services
6	Delays in obtaining scientific equipment	• Insufficient availability of pilot plants • Inadequate maintenance and repairs service
7	Difficulty of access to scientific literature	Inadequate computerized data processing services
8	Inadequate technical services	Uneasy access to S&T computerized databases
9	Insufficient availability of pilot plants	Uneasy access to scientific literature
10	Poor quality of ordinary scientific equipment	Difficulty of access to computerized databases
11	Inadequate information service	
12	Insufficient quality of ordinary scientific equipment	
	Absolute coherence = 0.3127 Intensity = 0.5229 Absolute dominance = 0.1667	Absolute coherence = 0.3544 Intensity = 0.4992 Absolute dominance = 0.1770

There are important differences in India and China about constraints relating to equipment and facilities. Among the set of five most important factors, only two factors, viz. insufficient quantity of specialized scientific equipment and bad quality of specialized scientific equipment, are common. Inter-country differences in the perception of constraints are summarized below.

- Difficulty in access to computerized databases is the most important constraint in India, whereas this constraint is relegated to the ninth rank in China.
- Inadequate repair and maintenance facilities are the second most important factor in India. In China, this factor is relegated to the sixth rank.
- Inadequate computerized data processing services is the third most important factor in India, but not in China, where it occupies the seventh rank.

- Delays in obtaining scientific equipment are the second most important factor in China, but in India its importance is much less. This factor occupies the sixth rank in India.
- Inadequate information services are the third most important factor in China, possibly due to the language barrier. In India it is not an important factor; it occupies the 11th rank.
- Inadequate technical services occupy the fifth rank in India, whereas it occupies the eighth rank in India.

Factors relating to working conditions for research

The matrix of fuzzy relations among different alternatives indicates that none of the cells exceed the threshold of simple majority, both in the Indian and Chinese data. This should not be seen as alarming, since the respondents had to choose only four out of 14 alternatives. The values of absolute cohesion and absolute dominance are somewhat higher for India than for China, implying greater consensus among the Indian respondents than among the Chinese respondents (Table 4).

There are important inter-country differences in the perception of constraints pertaining to work environment. Among the set of five most important factors, only one factor, viz. opportunities for professional contacts abroad, is common. In China, it occupies the second rank, whereas it occupies the fourth rank in India. Inter-country differences are briefly discussed below:

- Time spent on scientifically unproductive work is by far the most important factor in India. In China, it occupies the sixth rank.
- Poor human relations are the second most important factor in India, whereas in China, its importance is relegated to the 12th rank.
- Power politics and gamesmanship is the third most important factor in India, but its importance is quite low in China, where it occupies the 10th rank.
- Insufficient opportunities for professional contacts within the country is the most important factor in China, but it occupies the fourth rank in India.
- Insufficient working floor-space is the fourth most important factor in China. In India, this factor has the lowest rank.
- Inadequate administrative services is the third most important factor in China, but not so important in India (12th rank).

Table 4: Factors relating to work climate, general facilities and services

Rank	India	China
1	Time spent on scientifically unproductive tasks	Insufficient opportunities for professional contacts within the country
2	Poor human relations in the project	Insufficient opportunities for professional contacts abroad
3	Power politics and gamesmanship of institution	Inadequate administrative services
4	Insufficient opportunities for professional contacts within the country	Insufficient working floor-space
5	Insufficient professional co-operation within the project	Inadequate training and/or career development facilities
6	Inadequate training and/or career development facilities	Time spent on scientifically unproductive tasks
7	Inadequate co-operation from other projects	Too much distraction: noise
8	Professional rivalry	Inadequate co-operation from other projects
9	Inadequate office equipment	Inadequate office equipment
10	Insufficient opportunities for professional contacts abroad	• Power politics and gamesmanship of institution • Insufficient professional co-operation within their project
11	Too much distraction: noise phone calls, visits etc.	Insufficient concern within the project for meeting the objective assigned to it.
12	Inadequate administrative services	Poor human relations in the project
13	Insufficient concern within the project for meeting the objective assigned to it	Professional rivalry
14	Insufficient working floor-space	
	Absolute coherence = 0.3948 Intensity = 0.4880 Absolute dominance = 0.1927	Absolute coherence = 0.3505 Intensity = 0.4410 Absolute dominance = 0.1546

Factors relating to financing and management of research

The matrix of fuzzy relations among different alternatives indicated that 24 out of 182 cells exceeded the threshold of simple majority in the Indian data, which means that about 13 per cent of preferences were expressed in a very clear manner. In the case of China, none of the cells exceed the threshold of simple majority. India scientists were more definitive in their perceptions

of constraints compared to their counterparts in China. The values of absolute cohesion and absolute dominance are also higher for India than for China, implying greater consensus among the Indian respondents. The raking of different factors in these two countries may be visualized from Table 5, which is self-explanatory.

Table 5: Factors relating to financial resources and management practices

Rank	India	China
1	Inappropriate level of total funds available to the project (s) in the unit	Inappropriate level of total funds available to the project (s) in the unit
2	• Inadequate general policy guidelines given by higher authorities/ sponsors regarding research project(s) of the unit • Poor organisation of the work within the institution	Inadequate salary scale
3	Instability of the projects' regular budget	Inadequate staffing policy of the institution
4	Excessive number of research projects conducted simultaneously	Inadequate professional background of the project head
5	Inadequate distribution of work in the project	Bad organisation of the work within the institution
6	Inadequate professional background of the project head	Inappropriate administrative regulations and/or administrative constraints
7	Inadequate salary scale	Inadequate general policy guidelines given by higher authorities/sponsors regarding research projects of the unit
8	Defective leadership of the project head	Inappropriate research topics assigned to the respondent
9	Inappropriate research topics assigned to the respondent	Indifference of institution's governing board towards e-research work in general
10	Inappropriate administrative regulations and/or administrative constraints	Instability of projects' regular budget
11	Inappropriate financial regulations of the institution	Inadequate distribution of work in the project
12	Indifference of institution's governing board towards research work in general	Inappropriate financial regulations of the institution
13	Inadequate staffing policy of the institution	Excessive number of research projects conducted simultaneously
14		Defective leadership of the project head
Absolute coherence = 0.3738 Intensity = 0.4905 Absolute dominance = 0.1834		Absolute coherence = 0.3245 Intensity = 0.3773 Absolute dominance = 0.1224

Table 6: Ten most important factors inhibiting the functioning of research projects (All factors taken together)

Rank	India	China
1	Time spent on scientifically unproductive tasks	Inadequate professional background of scientists or engineers vis-à-vis the demands of the assigned research work
2	Power politics and gamesmanship of the institution	Insufficient quality of specialized scientific equipment
3	Poor human relations in the project	Insufficient number of qualified scientist/engineer in the project
4	Inadequate professional background of scientists or engineers vis-à-vis the demands of the assigned research work	Delays in obtaining scientific equipment
5	• Difficulty of access to S&T computerized databases • Delays in obtaining scientific equipment	Insufficient opportunities for professional contacts abroad
6	Bad organisation of the work within the institutions	Insufficient opportunities for professional contacts within this country
7	Poor quality of specialized scientific equipment	Inadequate information services
8	Instability of projects' regular budget	Inadequate professional background of scientists or engineers vis-à-vis the demands of the assigned research work
9	Defective leadership of the project head	Poor quality of specialized scientific equipment
10	• Inadequate training and/or career development facilities • Difficulty of access to scientific literature	Inadequate salary scale
Absolute coherence = 0.4871 Intensity = 0.2076 Absolute dominance = 0.1011		Absolute coherence = 0.4113 Intensity = 0.2002 Absolute dominance = 0.0824

There are similarities and differences in the ranking of factors inhibiting research and development work in India and China. Inappropriate level of project funding is by far the most important factor, both in India and China. In India, this constraint is compounded by another factor, *viz.* "thinning of resources on too many projects", which occupies the fourth rank. In China, thinning of resources on too many projects is not an important factor (13th rank).

Other most important constraints are:

India: Instability of budget, thinning of resources, inadequate policy guidelines and bad organisation of work.

China: Inadequate salary scales, inadequate staffing policy, inadequate professional competence of the project head and bad organisation of work are the most important inhibitors of research work.

Inadequate salary scales is perceived as the *second* most important inhibitor in China, but it ranks seventh in India. Inadequate policy is perceived as the second most important factor in India, but its importance is relegated to the seventh rank in China. Inadequate staffing policy is an important factor in China (third rank), but not in India, where it occupies the lowest rank.

Overall ranking of factors

The matrix of fuzzy relations among different alternatives indicated that none of the cells exceeded the threshold of simple majority in both India and China. This was expected since the respondents had to choose and rank only six out of 49 alternatives. The values of absolute cohesion and absolute dominance are somewhat higher for India than for China, implying greater consensus among the Indian respondents than their counterparts in China. Table 6 shows the top ten inhibiting factors in these countries.

There are significant differences in the perceptions of scientists in India and China. Among the top ten factors, only two factors are common, *viz.* inadequate professional background of scientists and delays in obtaining scientific equipment.

- Time spent on scientifically unproductive tasks is the most important factor in India, but not in China (17th rank).
- Power politics is the second most important inhibitor in India, but not in China (19th rank).
- Poor human relations is the third most important inhibitor in India, but not in China (31st rank).
- Difficulty in accessing computerized databases is the fifth most important factor in India. This factor does not have any importance in China (41st rank).
- Inadequate quality of scientific equipment is the second most important factor in China, but not in India, where is ranks 17th.
- Insufficient number of qualified scientists and engineers is the third most important factor in China, but not so in India, where this factor ranks 20th.
- Lack of opportunities for professional contacts abroad is the fifth most important inhibitor in China, but not so in India (27th rank).

Discussion

An important function of research management is to optimize the utilization of human and material resources invested in research and development work. This essentially implies that various constraints in the research environment, both spiritual and material, are effectively mitigated. Constraints in the research environment not only affect the performance and productivity of scientists, but also their motivation and morale. In this paper an attempt has been made to identify the most significant constraints, perceived by the scientists in two countries – India and China.

Bad organisation of work, wastage of time on scientifically unproductive paper work, power politics and gamesmanship in research institutions, poor human relations, difficulty in accessing scientific databases, delays in acquiring specialized scientific equipment (possibly due to cumbersome administrative procedures), and inadequacy of professional competence of scientists are cited as the most important inhibitors by the Indian scientists.

In China, most important constraints are related to professional contacts within and outside the country, insufficient quality of scientific equipment and inadequacy of scientists and engineers, both in terms of quantity and professional competence vis-à-vis the demands of research projects and bureaucratic delays.

Scientific research is essentially an information conversion process. Its input is information and so is its output. Obviously, the quality of output would depend upon the quality of information input. Difficulty in accessing computerized databases is the fifth most important constraint in India, but this factor does not have any importance in China (41st rank).

In a nutshell, constraints in scientific research in China by and large relate to infrastructure, whereas those in India relate to management.

References

Frank M. Andrews, (Ed) (1979), "Scientific Productivity – the effectiveness of research groups in six countries", Cambridge: Cambridge University Press; Paris: Unesco.

A. Chawla, J.P. Singh (1998), "Organisational environment and performance of research groups", Scientometrics, Vol. 43, No. 3, 373-391.

R.T. Eckenrode (1969), "The utility of systems models and development models for practitioners", In: Bennis, W.G., Benne, K.D. and Chin R. (Eds), The Planning of Change, New York; Holt, Rinehart and Winton, Eckenrode.

P.S. Nagpaul, A. Chawla (1995), "Empirical Assessment of a multivariate model of relationship between resource inputs and R&D performance", In M.E.D. Koening, A Bookstein (Eds), Proceedings of the Fifth Biennial Conference of the International Society for Scientometrics and Informetrics, Medford, NJ: Learned Information Inc.

P. Nijkamp, H. Voogd (1965), "Weighting multiple criteria", Management Science, 12, 3: 116-129.

V. Stolte-Heiskanen (1979), "Externally Determined Resources and the Effectiveness of Research Units", In Frank M. Andrews, (Ed). Scientific Productivity—the effectiveness of research groups in six countries, Cambridge: Cambridge University Press; Paris: Unesco. 121-153.

□

The reason people blame things on the previous generations is that there's only one other choice.

– Doug Larson

Feature

Corporate Governance of Management Institutions: The Total Quality Way

Vijaya Bandyopadhyaya & Ashis K. Pani

In management institutions, both quality and governance issues have become very important in recent times, influenced by all major educational stakeholders. This paper attempts to bring out the various issues related to corporate governance of institutions and how they can marry the proven TQM techniques with governance strategies to ensure their survival and growth in the present competitive environment.

Vijaya Bandyopadhyaya is a Senior lecturer at IBAT School of Management, KIIT, Bhubaneswar and Ashis K. Pani is an Associate Professor at XLRI Jamshedpur School of Management, Jamshedpur.

The issue of governance in management institutions has assumed great importance in recent times. This is true for all institutions, irrespective of their types of ownerships. However, the large number of new private institutions are under the watchful eyes of the accrediting bodies, rating agencies and the student and corporate community. Transparency and fairness at least to direct stakeholders (students, corporates or faculty) is of utmost importance to them if they are to attract the best from the country in terms of type and number of students and faculty, or companies that come for placement. Even for management departments of or institutions under government-aided universities or the Indian Institutes of Management (IIMs), accountability has become an issue of utmost concern (Pandey, 2004).

With increasing global competition, quality issues are obviously becoming more and more important. Proper application of Total Quality Management (TQM) at the strategic level will not only ensure the best quality of graduating students but ensure that best practices are adopted in institutional governance as well. Improved governance will, in turn, ensure proper TQM implementation (Kletz, 2002; Ridley, 1997).

This paper highlights the importance of corporate governance to management institutions highlights and how the TQM (Total Quality Management) strategies and governance strategies may be integrated to ensure their sustained competitiveness.

Corporate Governance in Management Institutions

Corporate governance

Corporate governance, used often as a synonym for sound management, transparency and disclosure, is attracting a good deal of public interest because of its

importance in economic and social well-being. It provides incentives and performance measures to achieve business success, and also provides accountability and transparency to ensure equitable distribution of the resulting wealth. Corporate governance as an issue began to gain importance with the rise of corporate raiders since 1970s and gained impetus with globalization, when companies in order to raise capital globally, had to be transparent in their economic and non-economic objectives.

The following definitions (Encyclopaedia of Corporate Governance) will help in understanding the broad meaning and varied perspective in which this term is used:

"Corporate governance is a field in economics that investigates how to secure/motivate efficient management of corporations by the use of incentive mechanisms, such as contracts, organizational designs and legislation. This is often limited to the question of improving financial performance, for example, how the corporate owners can secure/motivate that the corporate managers will deliver a competitive rate of return". (Mathiesen, 2002).

"Corporate governance deals with the ways in which suppliers of finance to corporations assure themselves of getting a return on their investment". (Shleifer and Vishny, 1997).

"Corporate governance is the system by which business corporations are directed and controlled. The corporate governance structure specifies the distribution of rights and responsibilities among different participants in the corporation, such as, the board, managers, shareholders and other stakeholders, and spells out the rules and procedures for making decisions on corporate affairs. By doing this, it also provides the structure through which the company objectives are set, and the means of attaining those objectives and monitoring performance". (OECD, April 1999).

"Corporate governance - which can be defined narrowly as the relationship of a company to its shareholders or, more broadly, as its relationship to society -....", from an article in the *Financial Times* (1997).

"Corporate governance is about promoting corporate fairness, transparency and accountability" (J. Wolfensohn, 1999).

"Some commentators take too narrow a view, and say it (corporate governance) is the fancy term for the way in which directors and auditors handle their responsibilities towards shareholders. Others use the expression as if it were synonymous with shareholder democracy. Corporate governance is a topic recently conceived, as yet ill-defined, and consequently blurred at the edges...corporate governance as a subject, as an objective, or as a regime to be followed for the good of shareholders, employees, customers, bankers and indeed for the reputation and standing of our nation and its economy" (Maw, 1994).

The characteristics of good governance are shown in Figure 1.Good governance assures that corruption is minimized, the views of minorities are taken into account and that the voices of the most vulnerable in society are heard in decision-making. It is also responsive to the present and future needs of society.

All institutions fulfill public goals. However, those receiving a significant part of their annual budget from taxpayers have a greater responsibility to meet the needs of the public. The need is also linked to economy as employers recruit graduates and contact faculty for research and technical assistance in resolving problems.

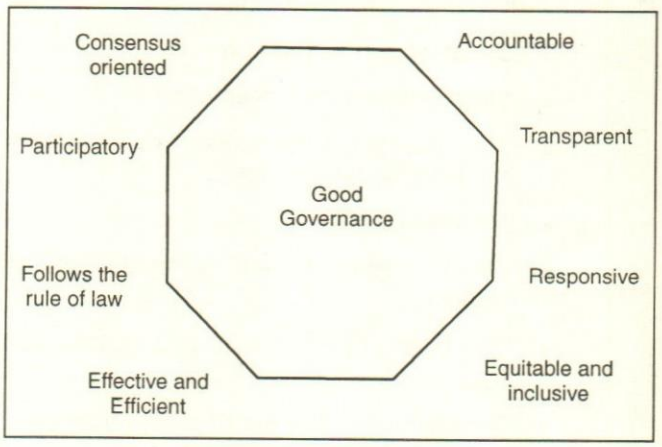


Fig. 1. Characteristics of good governance (from http://www.unescap.org/huset/gg/governance.htm)

Corporate governance as a parameter for business school accreditation

The authorized government agencies for accreditation of institutions play a major role in

- helping the institution to know its strengths, weaknesses and opportunities,
- identifying internal areas of planning and resource allocation,
- providing funding agencies objective data,
- providing employers and society reliable information on the quality of education offered

The National Assessment and Accreditation Council (NAAC) of the University Grants Commission (UGC) gives importance to Healthy Practices as an important criterion for institutional accreditation. This criterion analyses information on innovative and unique practices that add to academic ambience. The focus is, inter alia, on

- Mission statement and goals
- Master plan for institutional growth
- Stakeholder feedback for functional improvement
- Innovations in management and communications
- Quality enhancement strategies
- Complementary systems like self-financing courses and need-based courses

The National Board of Accreditation (NBA) of All India Council For Technical Education (AICTE) also gives substantial weightage to governance under the following heads:

- Infrastructural Performance Indices
  - Organisation and its mission
    - Organisation and Governance
    - The Founding Group (Past involvement in the field i.e. track record)
    - Mission and Goals
    - Organizational Values (philanthropic activities)
    - The Board of Governors and its composition
    - Involvement of the Board in Governance
    - Leadership
- Management
  - Institutional Head, Background and Professional Standing
    - Administrative Structure
    - Planning and Monitoring
    - Involvement of Faculty in Administration
    - Organizational Effectiveness (including Management, Faculty, Student attitudes & commitments)
- Infrastructural Performance Indices
  - Financial & physical resources and their utilization
    - Capital Budget
    - Operational Budget
    - Maintenance Budget
    - Development Resources and Budget
    - Utilization of surplus, if any
    - Formation of a separate corpus fund
    - Audited Statement of Accounts
- Academic Performance Indices
    - Recruitment Procedures (Transparency in recruitment)
- Admissions
    - Central or Institutional
    - Selection Criteria
    - Integrity of the System

Business school rankings

Management institutions are being rated and ranked by different agencies throughout the world. There are debates about the wide disparities between and the correctness of parameters and measurement scales used for ratings. However their value in communicating an expected quality level of the institutions to the prospective students, recruiters and also the schools themselves cannot be undermined. The objectives of ranking are quite different from those of accreditation. According to Dr. Dharni P Sinha: "While ranking gives a snapshot of a B School at a particular point in time relative to other B Schools, accreditation reflects its internal capabilities to meet and excel, benchmark quality standards and its capacity to grow over time. Accreditation focuses on the quality assurance of the B School. Ranking looks at the school from the point of view of the stakeholders." (http://www.vedpuriswar.org/articles/Indian Cases/Business School Surveys in India_2003.pdf)

Ranking of Business Schools, introduced in our country in 1998 by COSMODE (Business World Survey), showed the beginning of awareness among stakeholders for the need to differentiate between different schools. COSMODE'S initiative in ranking business schools was followed by C-fore (Outlook), MARS (Business India) and ACNielson (Business Today).

COSMODE ranked schools on the basis of 360° feedback: from corporate recruiters, students, faculty and alumni yielding perceptual data that was supplemented by hard information. Governance has been an important perceptual parameter for rating from the

beginning, with academic environment and quality of administration as important elements of both faculty and student scores. From year 2000 greater emphasis was given to objective data than perceptions, and governance was included as an important parameter here as well. C-fore's survey gave a 20% weightage to stakeholders' satisfaction, the perception scores being 160 for recruiter and 50 each for faculty and students satisfaction (Bhatia, 2002). Recent C-fore survey still keeps 20% weightage on perception but points are increased to 200 for recruiter and 60 each for faculty and students satisfaction (Outlook, September 27, 2004). However, COSMODE experience has shown that governance is not an equally relevant factor for all types of ownerships, especially university/ state supported institutions (Sinha, 2004).

In the All India Management Association (AIMA) - Business Standard survey also, governance is an important parameter. "While there are institute-specific variations across all parameters, the key differentiator is apparently the quality of corporate governance. Governance, which carries the lowest weightage in the AIMA survey, is crucial to ratings at the top of the totem pole because inter-institute quality differences are not that large in this group" (Indian Management, 2003).

Causes of rising concern for corporate governance

The need for accountability and the need for academia to regain the unquestioned trust of the greater community have been recognized (Burkhalter, 1996). The following reasons are attributed for the rising concern about corporate governance in management institutions in our country and their increased accountability to stakeholders:

- Increased competition due to sheer rise in the number of institutions. The effect of competition will be felt to a greater extent once the higher education sector gets opened up under the General Agreement on Trade in Services (GATS)
- Varied forms of institutional ownership
- Increased autonomy for public funded institutions
- Increased costs/fees charged from stakeholders

The effect of competition will be felt once the higher education sector gets opened up under the GATS.

"The students expect from institutions what they expect elsewhere - better service, lower costs, higher quality and a flexible mix of products that satisfies their own sense of what a good education ought to provide" (Zemesky, 1993). According to Prof. I.M. Pandey, governance includes issues of autonomy and accountability. Autonomy, intended to increase flexibility of institutions, encompasses three areas - academic, institutional and financial. He says that autonomy of publicly funded institutions also implies societal autonomy. He stresses the importance of putting the governance board in place in a fair and transparent manner and ensure academic autonomy and freedom of decision making to the faculty. Financial autonomy i.e. freedom to raise and use own funds and use government funds, is directly linked to institutional autonomy. However he cautions that "the idea that those who fund higher education should have the right to determine how funds are spent might erode autonomy and would be dysfunctional to the efficient and effective functioning of higher education institutions (HEIs). Intellectual freedom may be eroded if organizations funding research desire specific results. The issues of governance of HEIs become more complex as there are no directly identifiable owners and they have multiple sources of funds in the form of grants and donations". (Pandey, 2004)

In our country also, like in UK, Canada, Australia or New Zealand, direct government financial support to universities and other institutions are dwindling. This means that these institutions have to seek alternative sources of finance from fees, projects or other sources. In such situations, the erstwhile influence government had on the financial affairs of the university, through membership of governing body, may not be proper. Universities and other institutions obviously will want greater control over their own governance. (Marks, 2002). Accountability cannot be ensured without financial autonomy. The tension between a principal funder and an institution of academic excellence is a continuing one. This was reiterated in the concern of rising HRD Ministry intervention in the IIMs "..... concerted attempts to undermine the centres of excellence" (Sinha, 2004).

Governance system in management schools

The best management schools worldwide have an active, accountable and effective governance system. The system consists of (Chandra, 2003):

1. Advisory boards

- Board of Governors consisting of professionals

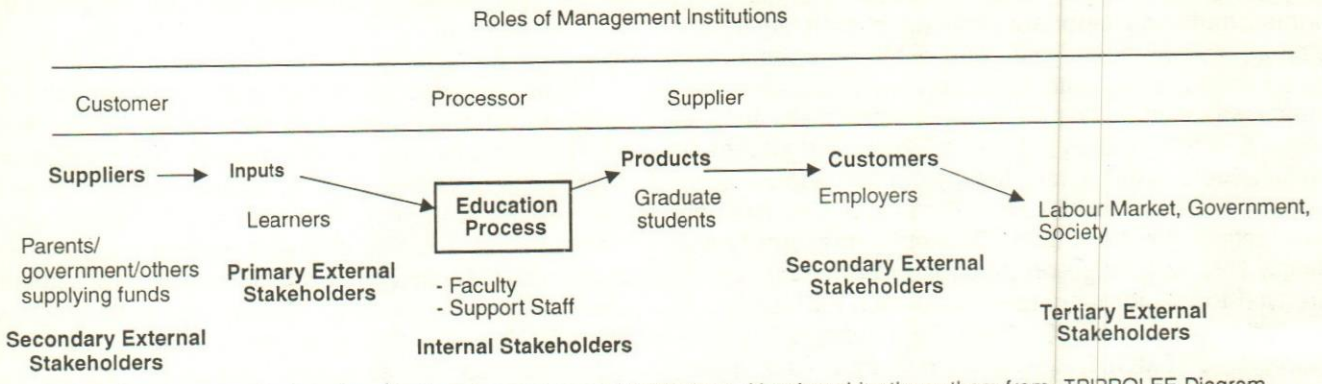


Fig. 2. Stakeholders of education ad roles of manageement institutions. (developed by the authors from TRIPROLEE Diagram (Juran, 1992) and Sallis Figure on Customers of Education (Fig. 2.3 p. 25 Sallis, 1996)

from business and other walks of life who have excelled in their own profession and provide very broad policy guidelines, help raise funds and provide linkage with external environment

- International Advisory Board: sometimes international members form a separate advisory group (including high profile international alumni) and advise school on international programmes, international research and global fundraising.

2. School's governance structure

- School leadership headed by the Dean (academics) and Director (non-academic)
- Support personnel often from management profession.

Roles of management institutions vis-à-vis its stakeholders

Management institutions are primarily service providers. The service provided is education that may be defined as value added to learners.

The stakeholders (often termed as customers) are the beneficiaries of education service, who provide funds and directly or indirectly have some stake in the management institution. The students/learner is the primary external customer (also called clients). The secondary customers have a direct stake in the education of a particular individual or an institution. Tertiary customers such as future employees, government and society as a whole have a less direct but nonetheless crucial stake in an institution.

The institution may be thought to have three generic roles. The central role is that of a processor, converting learners (students entering the system) into value added products. It acts as a customer when parents, governments or students themselves supply funds to the institution. Suppliers may also include alumni or companies who may provide support for research centres and named chairs in disciplines of their choice (Marks, 2002). It acts as supplier when the products processed out of the institutional system fulfill the requirements of the employers (the corporates where they join) or indirectly the labour market, government and society as a whole. The students have the dual role of being both products and customers of the institution.

Figure 2 shows the triple role of management institutions and how different stakeholders may be classified (Sallis, 1996; Juran, 1992).

How important is each stakeholder?

The weightage given to the perceptions of various stakeholders by rating agencies to a great extent speaks of the perceived importance of each of them. Employers or recruiters from the corporate are undoubtedly the most important. They are the takers (customers) of the products of the institutions viz. the graduating students. They judge the quality of the products and the institution needs to groom the learners to satisfy them. They provide student placement - a criterion on which all other stakeholders seem to judge a management institution. Transparent dealings with stakeholders have a great impact on the quality of students and also enhance their acceptability to corporations.

The faculty members are by far the most important internal stakeholders. This has been recognized worldwide. "The university's top administrators are by and large academics-turned-administrators, who may have professional managers reporting to them, but who implement policy and manage the affairs of the university. Of course, not every academic is cut out to be an administrator, but even at those epitomes of the ivory tower,

the Oxbridge colleges, the dons collectively decide policy for their college, sometimes even quickly. This model - in effect a partnership of faculty - may well be appropriate for business schools which have financial autonomy from their parent universities, but not yet governance autonomy. The governing body of the business school would resemble the governing body of a professional partnership, such as a law firm or an accounting partnership. There would still be need for the parent university to be represented, and for various outside stakeholders as well, such as significant supporters of the school, but the main representation on the governing body would be the representatives from the faculty" (Marks, 2002).

In India also, the powers that faculty enjoy in institutions of academic excellence are best portrayed in the following words: "IIMA has a genuinely participative, decentralized and transparent governance system. In theory, almost all the powers are vested in the Board of Governors and the Director. In reality, much of the decision making is with the committees and individuals. The faculty, for instance, through various committees, has considerable say in the selection of students and faculty members, in faculty promotions, in the content of the academic and training programmes that are offered, in the research that is funded and even such financial decisions as the fixing of fees. Individual faculty members have freedom to design new courses and training programmes, decide the course content and pedagogy, and what research to undertake" (Khandwalla, 2004).

The student is obviously a very important stakeholder, being the link of the institution with all other stakeholders and experiencing the service delivery first hand. However, the extent to which their views may be taken into account in academic matters is a point of debate since they may not know what they need to learn. Higher education institutions (HEIs) have a multiplicity of customers and "need to consider the relative importance of each customer group, balancing and reconciling the interests of diverse groups rather than favouring one against the other" (Ho & Wearn, 1995).

Like in any organization, each department/individual needs to serve a set of internal customer departments and each customer himself has a set of internal customers to whom he is accountable. The professional educator can observe the needs and wants of students, then balance those with the needs of other customers who may have a stake in the education programme and the future graduates (like employers or other educators who provide advanced instruction). A teacher is a customer of other educators as he cooperates to integrate the curriculum. Faculty and staff become customers of administrators who have to weigh and cater to their needs and requests (Spanbauer, 1995).

Total Quality Approach to Corporate Governance

Quality

Although most people have their own perceptions about what constitutes good quality and what does not, quality is a difficult and illusive term to define. In quality assurance and TQM, the term quality is used not as an absolute but as a relative concept i.e. it is not an end in itself, but a means by which the end product is judged to be up to standard/ specification. The relative definition also has two aspects to it:

- Procedural concept that is concerned with measuring up or conforming to a predetermined specification. Proving, approving and reporting are key descriptors of this largely instrumental approach used to ensure consistency and conformity to 'hard' indicators of measurable performance
- Transformational concept that has more to do with organizational transformation making it more 'customer' rather than product oriented. In addition to embracing the measurable aspects of quality, it also seeks to integrate softer and more intangible aspects of quality like care, customer service and social responsibility (Sallis, 1996).

".. the quality of knowledge and research and skills which will give competitive advantage to a country and not cheap unskilled labour or even natural resources" (Patel, 2004).

Boards of trustees, governments, employers, parents and students are increasingly concerned about 'access to' and 'quality of higher education' "as a means toward employment and economic security" (Lewis & Smith, 1994).

Total Quality Management

Dahlgaard (1995) believes that the definition of quality put forth by Imai - quality is anything that can be improved - is true for any organization, including educational institutions. A way can always be found to achieve higher quality without increasing the cost, and forms the basis for continuous improvement. This forms the basic premise for use of Total Quality Management (TQM) in management institutions.

TQM can be defined as "the totally integrated effort for gaining competitive advantage by continuously improving every facet of organizational culture" (Tobin, 1990).

A more comprehensive definition (Witcher, 1990) explains the three words: total - every person in the firm is involved (including customers and suppliers); quality - customer requirements are met exactly; management - senior executives are fully committed. (Besterfield, 2001)

TQM is thus a practical and strategic approach to running an organization to achieve appropriate levels of quality in a consistent fashion that meets or exceeds the needs and wants of customers. This small scale, highly practical and incremental approach focusing on long-term change assures that implementation is not expensive. However, it requires a change in culture, attitudes and working methods that are extremely difficult and time taking to bring about. The staff needs a suitable environment to work in and encouragement and recognition of their achievements. Effective leaders with a vision act as change agents, making this transformation possible.

TQM also encompasses competitive benchmarking for improvement. It involves systematically searching for best practices and then adopting them by trying to do as well or better in competition.

TQM in Education

"Total Quality Management is a philosophy of continuous improvement, which can provide any educational institution with a set of practical tools for meeting and exceeding present and future customers needs, wants and expectations" (Sallis, 1996).

TQM may be used in educational institutions (Vazzana, 2000) in

- the curriculum
- non-academic functions
- academic administration
- the core learning process

The leader plays a crucial role in TQM implementation and organizational transformation (Heckman, 1993). He has to deal with highly educated faculty members who are often less amenable to change and less receptive to others suggestions. Another challenge and responsibility of leaders in higher education is to educate quality students while reaffirming faith in the principle of academic freedom and institutional autonomy: the ultimate basis for world-class standards in higher education (Stewart, 1995). When a vision among students, faculty and administration is shared on ways to improve the learning process, when faculty are rewarded for their classroom performance as well as research and publications and when leadership supports this vision through clearly defined mission and institutional goals, the quality improvement system will become firmly embedded within the halls and classrooms of academia (Burkhalter, 1996).

The potential benefits of TQM to higher education (Hill & Taylor, 1991) are as follows:

- Continuous and sustained organizational improvement
- Increased levels of external satisfaction
- Tangible and significant savings in operating costs
- Focus on the importance of interdisciplinary teams with faculty and administration
- New way of managing the organization-wide congruence, accountability and involvement
- Improvements in employee morale, commitment and motivation

The Decision Phases

The strategic process of TQM implementation includes the following steps (Ho & Wearn, 1995):

- Institution's broad aims and objectives (strategic directions) laid down by top management
- Staff at all levels made aware of institutional direction
- Implementation teams including quality steering committee and quality improvement teams, established
- Strategic directions broken down into objectives for each team
- Current situation assessed
- A documented implementation plan created
- Progress monitored as part of the Deming Cycle
- Review done to complete Deming Cycle

The Total Quality approach to Governance

There are several studies that discuss the application of TQM principles to higher education (Hill & Taylor, 1991; Lewis & Smith, 1994; Dahlgaard, 1995; Ho & Wearn, 1995; Spanbauer, 1995). However, very few deal

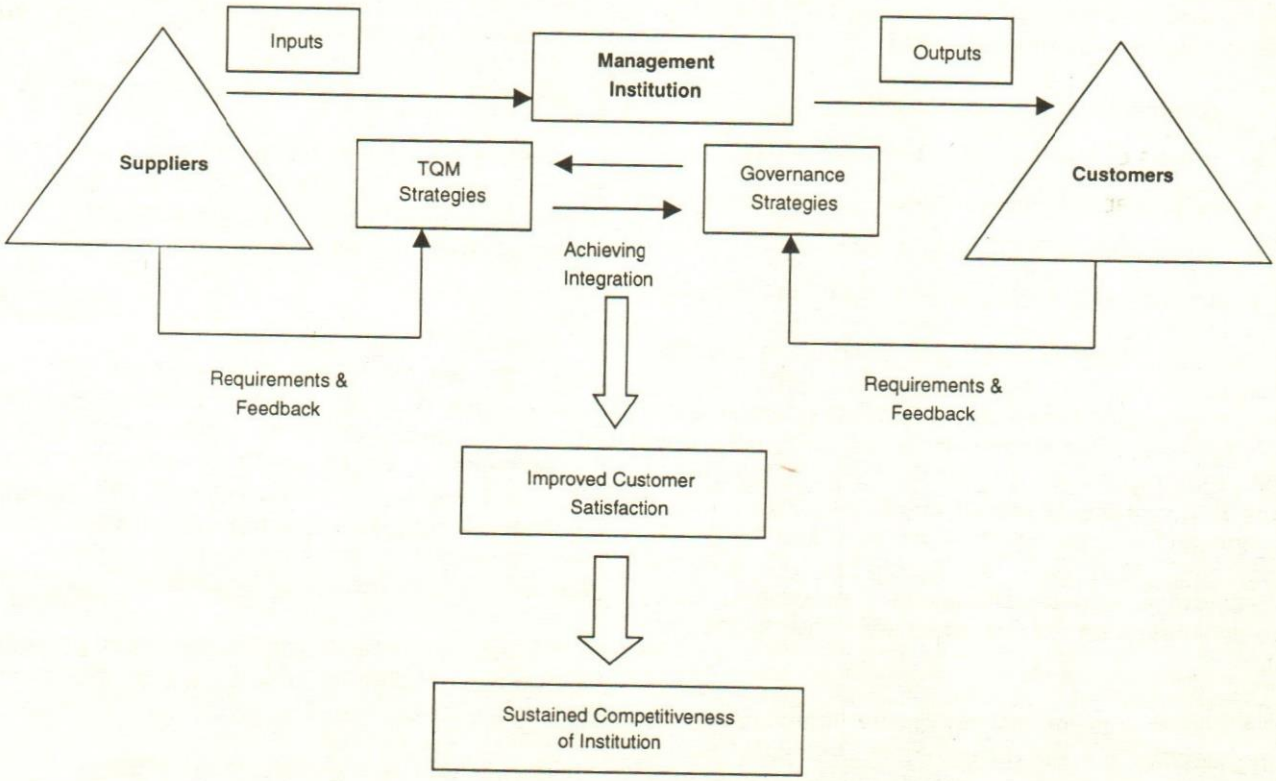


Fig. 3. The Quality Governance Link

with how to apply TQM to corporate governance (Ridley, 1997; Kletz, 2002).

The guiding principles of institutional governance and continuous quality improvement are compatible. The TQM approach requires that the institution give some thought to its internal processes, environment and the workforce that designs, manufactures and delivers its products or services. In reality, this means that the following targets will be set:

- maximisation of customer satisfaction;
- total commitment to quality;
- adaptation of the corporate culture so that tools and procedures can be set up.

The purpose of a quality approach in governance is rationalize and to increase the effectiveness of corporate practices. Quality is all about meeting and exceeding the customer's expectations. If the quality approach revolves around the implementation of either total or strategic quality management, all structures and actors in the organization concerned will have to be involved. There will necessarily have to be some thinking about the given organization's strategic plans viz. its vision, mission and objectives. A link between quality and governance strategies to achieve competitiveness of institutions is shown in Figure 3.

As total quality methods should involve all of the structures and actors in a given organization, there needs to be a participative and decentralizing mode of management meant to increase everybody's sense of responsibility, regardless of his or her hierarchical level.

Several issues need to be addressed when discussing the use of quality processes in the effective governance of educational institutions in general and business schools in particular. Have these processes been successful in business? Are they cost efficient? Can they be applied to the teaching-learning process?

Teaching and learning need to be continuously improved and assessed. Processes should be adopted to improve the quality of education, increase constituent involvement, empower faculty, and focus on the customer. Various studies have found that administrators and stakeholders believed that their TQM programmes were making a great contribution to organizational effectiveness and that the benefits were greater than the costs. Successful TQM programmes were associated with improved training, a greater degree of goal setting and continuous feedback from constituencies, group approaches to problem solving, and support of leadership.

However very few institutions adopt TQM practices; reasons cited are (Spanbauer, 1995):

- detrimental effects on creativity,
- threats of standardization and uniformity,
- lack of appropriate rewards,
- an emphasis on publishing, and
- professors not accustomed to working in teams

Although there is skepticism concerning the applicability of TQM to the core learning process, not using these quality concepts in the development, teaching, and assessment process is equivalent to not using TQM in the production or service areas of businesses. There is possibility of use of quality processes in the management of administrative, support, and academic departments. Many business schools use various forms of assessment and benchmark their processes. They may benchmark on the best practices in governance as well.

A critical area for making quality improvements in higher education is the development of strategic plans. Quality-oriented advisory groups help to improve strategic planning for demonstrating and improving effectiveness. Mission development, strategy determination, and the setting of goals may be accomplished at both the university and college levels.

The three important TQM techniques that may be used are:-

1. Stakeholder involvement,
2. Team training,
3. Use of scientific tools

Business schools need to involve stakeholders like employers, business leaders, and past students (alumni) in the development of curriculum. The use of advisory boards at the colleges and a majority of the departments are additional indicators of stakeholder involvement and empowerment. Further, the institute may use cross-functional teams for the purpose.

Business schools may improve their services through a variety of quality processes. Many are using a model of TQM that leaves most of the education process to the individual faculty member. However, time constraints, research needs, irregular teaching schedules, use of part-timers, organizational culture, and academic freedom makes it difficult to employ a comprehensive TQM programme in academia. Nevertheless, many business colleges are attempting the process, and some institutions are likely to succeed. Most institutions are at least likely to benefit from this attempt to improve the quality of their institutions by better serving their stakeholders.

Student enrollment, research productivity and student retention are important indicators of quality of institutes. They may choose TQM to distinguish itself from its competitors and to compete better in the market place.

Internally, faculty and staff implement TQM principles at several levels. For example, they may employ TQM principles in its various operations by defining customers and their requirements, improving the processes used to deliver services to customers and measuring customer satisfaction. All aspects of the institute may be analyzed for process improvement opportunities, including recruitment, advice, student records and teaching.

Through a university wide participatory process the following accountability questions may be answered (Burkhalter, 1996):

1. How well are we doing in our jobs?
2. How can we do them better in the future?
3. Do students achieve their goals?
4. Are they improved as corporate leaders?
5. How can we determine if our institution is focusing on its mission and achieving its other institutional goals?
6. Does our institution's access, price and quality of education meet the expectations of our students and parents?

Conclusion

With the increase in the number of management schools in our country, the environment is becoming increasingly competitive. The concept of continuous improvement in higher education is gaining importance. The implementation of quality assurance systems to improve the process and hence student quality, is no longer sufficient to ensure economic success. Outstanding institutions that have excellent quality and financial performances integrate their total quality management systems into their strategic plans. They continually benchmark and reassess their quality management systems. The implementation of TQM principles in the governance of management schools will ensure effective governance and satisfied stakeholders. On the other hand, proper TQM implementation for improving even the process and

product quality requires a transformation in the organizational culture. It is essential to have the requisite supportive organizational climate and a transparent and fair governance by the board, in which concern for quality and attention for the responsibility of each individual, are of top priority to ensure that best practice is adopted in the institute. This will ensure the sustained competitiveness of the institutions.

References

Besterfield, D. H. et al. (2001). "Total quality management." Asia: Pearson Education.

Burkhalter, B.B. (1996, April). "How institutions of higher education achieve quality within the new economy?" Total Quality Management. 7(2), 153-160.

Chandra, P. (2003, September). "Elements of a world class management school". Working paper No.2003-09-03, Indian Institute of Management Ahmedabad.

Dahlgaard, J.J. (1995, December). "Total quality management and education". Total Quality Management. 6(5). 445-456

Encyclopaedia of Corporate Governance., catalogue.bized.ac.uk/roads/cat/orgman.html

Heckman, P.E. (1993, July). "School restructuring in practice: reckonong with the culture of school". International Journal of Educational Reform. 2(3). 263-271

Hill, F.M. & Taylor, W.A. (1991). "Total quality management in higher education". International Journal of Educational Management.5, 7

Ho, S.K. & Wearn, K. (1995). "A TQM model for higher education and training". Training for quality, 3(2). 25-33

Juran, J.M. (1992). "Juran on quality by design: the new steps for planning quality into goods and services". New York: Free Press.

Kletz, P. (2002, 4th Quarter) "Can a public service ethos accommodate total quality methods?" European Business Journal, 14(4). 197

Marks, R. (2002, December). "Corporate Governance or Where Does Ownership Lie? Australian Journal of Management", 27(2). Retrieved on July 09, 2003 from www.agsm.unsw.edu.au/eajm/edit.html

Pandey, I.M. (2004). "Governance of higher education institutions". Vikalpa, 29(2), 79-83.

Patel, I.G., Khandwalla, P.N. & Paul, S. et al (2004). "Social context of management education: institution building experience at IIMs". Vikalpa. 29(2), 85-109.

Ridley, J. (1997, June). "Quality and governance: impact on each other. Total Quality Management", 8 (2/3), S253

Sallis, E. (1996). "TQM in education". London: Kogan Page.

Sinha, D.P. (2004). "Management education in India - perspectives and challenges". Hyderabad: ICFAI Books.

Spanbauer, S.J. (1995, December). "Reactivating higher education with total quality management: using quality and productivity concepts, techniques and tools to improve higher education". Total Quality Management, 6(5).

Lewis, R.G. & Smith, D.H. (1994). "Total quality in higher education". Delray Beach, FL: St Lucie Press

Stewart, D. M. (1995). "Holding onto Norms in a Sea of Criteria". In D. Ravitch (Ed.), Debating the Future of American Education. Washington, D.C.: Brookings Institution

Tobin, L.M. (1990). "The new quality landscape: total quality management". Journal of System Management. 14 (11).

Vazzana, G., Elfrink, J. & Bachmann, D. P. (2000, November/December). "A longitudinal study of total quality management processes in business colleges". Journal of Education for Business. 76(2).

Zemsky, R., Mossey, W.F. & Oedel, P. (1993). "On reversing the ratchet", Change 2(5), 56-62. □

Don't look too far ahead. Focus on what you're doing right now.

– Kent Tippy

Feature

Review of Privatisation of Electricity Distribution in Orissa

Sasmita Palo & Sweta Panigrahi

This paper illustrates the process of privatization of electricity distribution in the state of Orissa and gauges its outcome. The study discloses that privatization has brought about no appreciable improvement in the financial position, billing and collection efficiency, regularization of unauthorized meter and hooking position, reduction in T & D and AT & C loss percentage, and rural electrification level in the state.

Sasmita Palo is Reader, Tata Institute of Social Sciences, Mumbai, and Sweta Panigrahi is faculty at IGNOU campus, New Delhi.

Power is a concurrent subject in India with state governments managing the State Electricity Boards (SEBs) and the central government looking after bulk generating stations, inter-state transmission and policy matters. The SEBs were performing well till the mid-1980s, both technically and financially. Afterwards, most of the SEBs slinked into a catastrophe with deteriorating performance, high losses and low standing. Consumers were then confronted with frequent power cuts and fluctuating voltage. System losses became high all over India's transmission and distribution (T&D) networks. In 1992 - 93, the total financial losses attributable to T&D stood at Rs. 4,600 crore ($920 million). These losses reached an estimated Rs. 26,000 crore in 2001, which amounts to more than US $5 billion per year (CORE International, 2002).

To improve the financial health of the sector, the Government of India (GoI) opened up electricity generation to private investors, both foreign and domestic in October 1991, either as a licensee supplying power inside a specified area, or as a generating company selling electricity to a SEB. Accordingly, the Electricity Supply Act, 1948 and the Indian Electricity Act 1910 were amended, SEBs were unbundled, and plans were concocted to privatize distribution. Orissa is the first State in India as well as the first region in South Asia to carry out privatisation. With virtually more than 10 years of reform experience, Orissa continues to be one of the most intensely observed power sectors.

Backdrop of the Reform Process in Orissa

The origins of the Orissa power reforms can be traced to a World Bank-funded hydel project in the state, which got stalled in the early 1990s owing to rehabilitation issues. The World Bank therefore converted the loan into a reform-linked one and scripted, with the help of international consultants, a reform strategy which consisted of unbundling, corporatising

and privatising the power utility in the state. In course of time reform became imperative for the state on account of growing T & D losses, acute power shortage, mismanagement, inadequate investment, progressive increase in tariff rates, poor revenue collection and theft reduction, increasing burden of subsidy on the state, increasing gap between demand and availability of energy, political interference etc. (GoO, 2001).

The World Bank played a vital role in the entire reform process. On the basis of the recommendations of the Reform Consultants, it proposed a reform model that was later reviewed by a team of consultants led by ECC Inc. The proposed reform model was implemented in three phases. In the first phase (July 1994-March 1995), a Steering Committee, a Task Force, Project Management Group, and nine Working Groups were constituted to direct the implementation of reform and restructure the electricity sector. In the second phase (March 1995-August 1996), the Orissa Electricity Reform (O.E.R) Act was enacted and came into force with effect from 1st April 1996. Section - 3 of the Act mandated the setting of the Orissa Electricity Regulatory Commission (O.E.R.C) to oversee and regulate the power sector, revise the tariff rates, and discharge a number of other prescribed activities. Section 23 to 26 of the Act provided for the reorganisation of the electricity sector by resting O.S.E.B's generation, transmission and distribution assets, liabilities, proceedings, and personnel in separate entities through one or more Statutory Transfer Schemes.

Accordingly in that phase, the Grid Corporation of Orissa Limited (GRIDCO) was created to undertake transmission and distribution, Orissa Power Generation Corporation (O.P.G.C) to own and operate O.S.E.B's thermal plant, and the Orissa Hydro Power Corporation (O.H.P.C) was formed for the hydro plant. The Orissa Electricity Regulator Commission (O.E.R.C) was constituted to set tariff rates and insulate the electricity industry from political decisions and rigid bureaucratic controls. And in the third phase (March 1997 onwards), the four distribution zones were privatised and accordingly, four distribution companies i.e. Western Electricity Supply Company of Orissa Limited (WESCO), North Eastern Electricity Supply Company of Orissa Limited (NESCO), Southern Electricity Supply Company of Orissa Limited (CESCO), were established and licensed.

Privatisation of Electricity Distribution: Conceptual Issues

Since most of the electricity problems are centered around the distribution level, only a viable distribution business can ensure quick capacity addition, reduction of transmission and distribution losses and improvement in collection efficiency (Ministry of Power, 2002). Introduction of private capital in the power sector, if properly structured and implemented, is likely to engender the following advantages: improved public finances through sale of state assets and elimination of subsidies gradually; improved performance of power entities by introducing competition between different players, primarily by creating a wholesale power market, giving higher returns to those supplying power at lowest rates; lower consumer tariffs through creation of institutional framework for dealing with consumer concerns; attract more investment, including foreign investment; develop wider private share ownership in key economic activity; and improved revenue realisation at all levels, thus making services more efficient (Baijal, 1999).

A variety of models exist for instituting private sector participation in the power sector. Each model allocates different risks involved between the public and the private sectors. Generally, the greater the risks and control allocated to the private sector, the greater the incentive to improve performance as the resulting rewards accrued to the private units. These models include Service Contracts (2-5 years); Management Contracts (3-5 years); Leases (10-12 years); Concessions (15-30 years); Asset Transfer; and Before Operation Transfer (BOT) Contracts.

The Management Contract Model was adopted for privatisation of the distribution function in Orissa.

Phasing of Privatisation of the Distribution System

There are three approaches for phasing of privatisation in an environment where the information at hand is either capricious or very inadequate:

i. Decelerate in privatisation until information is considered to be of an adequate quality;

ii. Adoption of a two-phase approach, where the initial short-term arrangement such as management contract is agreed with a focus on collecting information, to be followed by a longer-term arrangement once reliable information has been obtained; and

iii. Adoption of a fast-track approach under the assumption that, in the absence of reliable information on the business, the prices paid will be low or possibly even negative (World Bank, 2000).

Privatisation of Electricity Distribution in Orissa

The major objectives of electricity distribution

privatisation in Orissa were to bring: *Operational Improvement* (to improve quality of service to consumers, operational efficiencies and reduce losses and to promote competition); *Financial Stability* (attract private investment into the distribution business, reduce the need for Government funding of the electricity sector; and contribute to increased economic growth in Orissa); *Employee Consideration* (to provide a stable environment for employees); and *Improved Management* (to introduce effective private management into the sector, and develop managerial effectiveness).

The Board of GRIDCO's recommended to the State Government to convert the four Distribution Zones into Distribution Companies on 11.7.1997 mainly through the joint sector/joint venture route. The Government of Orissa approved the Board's recommendations on 7.8.1997 for disinvestments of 51% of shares of each of four distribution companies to the private sector investors through a process of international competitive bidding. The stake of GRIDCO will be 39%, and the Employees Welfare Trust will hold the balance 10%. GRIDCO incorporated the four wholly owned subsidiaries for effecting transfer of distribution functions to those companies on 19.11.1997, and the then Chief Minister of Orissa announced the privatisation of four distribution companies on 27.11.1997. The entire privatisation process was carried out in the following two phases:

Phase-I: Adoption of a Two-Phase Approach (DOA)

In the first phase, DOA was awarded to Bombay Suburban Electricity Supply Company (BSES) for Central Zone in October 1996 for 3 years. DOA is like a management contract where a company carries out the O&M activities, while the assets and employees remain with the utility. Performance of this arrangement was to be reviewed every 6 months. Since there was no improvement in performance, the DOA was terminated after 6 months in April 1997 and it was decided to implement more fundamental privatisation.

Phase- II: Adoption of a Fast-Track Approach (Rapid Privatisation)

Adoption of fast-track approach lays emphasis upon rapid privatisation. Under this phase, privatisation took place in the following three stages.

Stage-I:	Qualifications of Companies/Consortia (November 1997-June 1998).
Stage-II:	Request for proposal (RFP) and lodgement of bids (July 1998 – Novemeber 1998).
Stage-III:	Negotiation and completion (December 1998 – September 1999).

Stage-I: Qualifications of Companies/Consortia (November 1997 - June 1998)

In this phase, 51 Companies/Consortia participated in the international bidding, but only 13 Companies/Consortia submitted their Statement of Qualifications (SoQs). Out of 13, four companies did not participate in the bidding process owing to reasons like the Asian economic crisis, Pokhran–II blast, unviable and small business, and regulatory risks. Out of the remaining bidders, the following three e.g. BSES, Singapore Power – Grasim, and TEC-Viridian were found to be technically qualified. BSES was selected for WESCO, NESCO, and SOUTHCO, and GRIDCO handed over their management to it with effect from 1.4.1999.

The AES Corporation, Jyoti Structure Limited, the pre-qualified bidder, was selected for CESCO w.e.f 1.9.1999. But as AES expressed its unwillingness to pick up 51% of the share in CESCO, during negotiation it was agreed that GRIDCO would provide the working capital of Rs.174 crores (deferred payments for power purchase), beyond which the working capital requirements would be the responsibility of AES. Unfortunately, a month later, a cyclone devastated Orissa and killed ten of thousands of people, destroying homes and villages and parts of the electricity network. AES said it had not insured the network and so the Indian government should compensate AES for either the $60 million cost of rebuilding the network, or the people of Orissa should pay three times as much for their electricity consumption. Dennis Bakke, CEO of AES, purportedly said, "People have to bear the cost if the government does not share the burden" (Quoted from Bisoi, 1999).

The Kanungo Committee (2001) further observed that: *AES apparently had come into CESCO hoping that they would get 2 per cent more of the shares in O.P.G.C, which would then give them 51 per cent shareholding in the generation company. When this did not materialise, AES started losing interest in CESCO.* It started defaulting in its payments to GRIDCO for bulk supply. On 25th July 2001, AES wrote to the Secretary GRIDCO seeking permission to sell its stake in CESCO, contrary to the shareholders' agreement, which stipulated a lock-in period of five years until March 31, 2004. It also offered an alternative i.e. selling of their shares to GRIDCO at a negotiated price. According to CESCO's own admission, it had piled up provisional liabilities of Rs.656 crores by September 2001. As GRIDCO deferred that request, at last AES left the scene in July 2001.On 26 August 2001, O.E.R.C in its order, entrusted the management of CESCO to a Chief Executive Officer (C.E.O), and this arrangement has been ongoing ever since.

Profile of Distribution Companies

Table 1 reports the present profile of four distribution companies. As the Table reveals, WESCO covers the maximum area, but population-wise CESCO tops the list. The percentage of consumers to total population is comparatively low in NESCO (4.3) followed by WESCO (4.8) and SOUTHCO (4.8), and CESCO (6.5). Under the new distribution systems distribution is done through 4 Zones, 14 Circles and 58 Divisions.

Table 1: Profile of the Four Discoms

Profile	NESCO	CESCO	SOUTHCO	WESCO	Total (Average)
Head-quarter	Balasore	Bhuba-neswar	Berhampur	Burla	-
Area Covered (.00 Sq. Km.)	28	29	47	48	152 (38)
Population (in lakhs)	91.80	130.16	87.12	92.75	401.83 (100.5)
Population / Sq. Km.	328	393	185	193	1099 (274 .7)
Consumers (in lakhs)	3,98,730	8,23,880	4,23,880	4,05,000	20,51,490 (5,12,872)
Consumers as a % of Population	4.3.	6.5.	4.8	4.8	20.4 (5.1)
Distribution Divisions	13	19	15	11	58 (14)
Distribution Circles	2	5	4	3	14 (3)
Employees	4,062	8,338	4,011	5,190	21601 (5400.2)

Source: Compiled from the data collected from CESCO, Bhubaneswar; WESCO, Burla; SOUTHCO, Berhampur; and NESCO, Balasore.

Performance Assessment of Discoms

In this section, the overall performance of Discoms is assessed taking into consideration seven parameters such as: payment of BST Bill, T & D loss percentage, AT & C loss percentage, billing and collection efficiency, consumers covered, metering and hooking position and electrification. Data on different performance parameters have been collected for the financial years 1st April 2000 to 31st March 2004. However, in certain cases, due to non-availability of up to date information, data up to March 2003 have been provided.

Payment of BST Bill

The supply business requires purchase of power by the Discoms from the transmission company (GRIDCO) for supply to consumers. The power purchase by the Discoms is metered at various grid sub-stations end and the Discoms are billed according to the meter reading at these points. This is exhibited in the various data recorded in the energy-billing centre (EBC) of GRIDCO and in the BST bill of GRIDCO raised on Discoms. Actual figures of billing raised by GRIDCO to the Discoms for the past four years are presented in Table 2 and in Figure 1.

Table 2: Payment of BST Bills

Year	Discoms	Input of Energy (MU)	BST bill of GRIDCO (Rs. in Cr)	Payment made to GRIDCO (Rs. in Cr.)	Percentage of Payment (%)
2000-01	C	4025.30	510.88	376.21	73.6
	N	2436.87	295.03	218.83	74.17
	W	2887.77	413.79	300.87	72.7
	S	1522.70	187.25	142.75	76.2
Average		2718.16	351.78	259.67	74.17
2001-02	C	4186.45	574.81	372.62	64.8
	N	2306.66	319.72	192.73	60.28
	W	2979.29	421.46	338.41	80.3
	S	1521.95	200.25	181.76	90.8
Average		2748.59	379.06	271.38	74.04
2002-03	C	4055.47	530.59	440.89	83.1
	N	2396.76	298.28	264.36	88.63
	W	3353.72	452.26	472.73	104.5
	S	1555.97	193.45	194.92	100.8
Average		2840.48	368.64	343.22	94.25
2003-04	C	3899.54	518.85	441.27	85.0
	N	2645.79	326.09	326.12	100.0
	W	3784.18	509.97	516.88	101.0
	S	1607.39	200.98	200.81	100.0
Average		2109.27	388.97	371.27	96.5

Note : C- CESCO; N-NESCO; W-WESCO; S-SOUTHCO for all Tables
Source: O.E.R.C, Bhubaneswar

It is revealed from both the Table and the Figure that, there is an appreciable rise in the percentage of payments of BST Bills made to GRIDCO by different Discoms in recent years. On an average, payment of the bill has increased from 74.17% in the FY (2000-2001) to 96.5% in the FY (2003-04). SOUTHCO has topped the list in this regard by clearing off 91.95 % (on an average) BST Bill during the period 2000-01 to 2003-04 followed by WESCO (89.37%), NESCO (80.77%), and CESCO (76.62%).

Table 3: Distribution Loss Percentage of Discoms

Year	Discom	Input (MU) / Billed (MU)	EHT	HT	LT	Total	Loss (MU)	% Loss
2000-01	C	4025.30	453.36	385.48	1379.68	2218.52	1806.78	44.9
	N	2436.87	487.50	355.46	514.52	1357.48	1079.39	44.3
	W	2867.77	565.67	347.26	716.06	1595.78	1238.78	43.2
	S	1522.70	1290.46	192.75	553.22	875.43	647.27	42.5
Average		2713.16	699.25	320.28	790.87	1511.80	1193.05	43.7
2001-02	C	4186.45	295.81	422.08	1425.15	2143.04	2052.41	48.8
	N	2302.66	291.99	279.69	556.63	1128.31	1174.35	51.0
	W	2979.29	611.48	291.77	692.53	1595.78	1383.51	46.4
	S	1521.95	136.34	192.22	577.53	906.08	615.87	40.5
Average		2747.59	333.91	296.44	812.96	1443.31	1306.53	46.7
2002-03	C	4055.47	497.18	362.31	1451.10	2310.59	1744.87	43.0
	N	2396.76	481.38	323.38	600.21	1404.97	991.79	41.4
	W	3353.72	987.71	307.94	773.63	2069.27	1284.45	38.3
	S	1555.97	160.52	202.33	584.09	946.94	609.03	39.1
Average		2840.48	531.69	298.99	852.26	1682.94	1157.53	40.5
2003-04	C	3899.54	487.03	383.66	1478.29	2348.98	1550.56	39.8
	N	2645.79	590.33	281.63	688.71	1560.68	1085.11	41.0
	W	3784.18	1197.54	379.06	836.29	2412.89	1371.29	36.2
	S	1607.39	149.94	215.18	607.13	946.94	635.14	39.5
Average		2984.22	606.21	314.88	902.605	1817.37	1160.525	39.12

Note: Figures in parentheses indicates % Loss at LT (Assuming HT Loss @ 8 %).

Source: O.E.R.C, Bhubaneswar

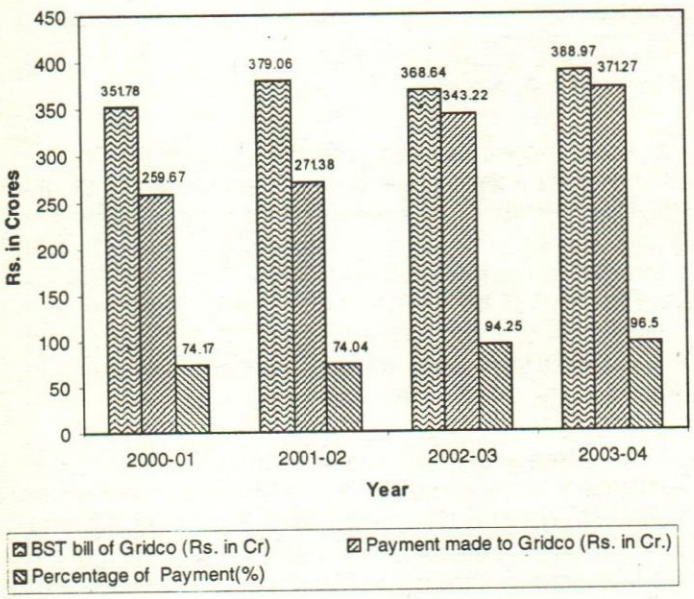


Fig. 1. Payment of BST Bills by Discoms

T & D Loss Percentage

Another important performance parameter is the determination of the total cost of distribution and retail supply. The energy received at grid sub-stations at 33 KV by the Discoms and supplied to the end-use consumers at different voltage levels entails both technical and commercial losses. O.E.R.C has fixed different targets for different Discoms as the benchmark level of T & D loss. The total T & D loss percentage incurred by different Discoms up to March 2004 are presented in Table 3 and Figure 2. These denote that T&D losses do not show any substantial improvement and remained at 45 per cent (pre-restructuring period loss figure) up to

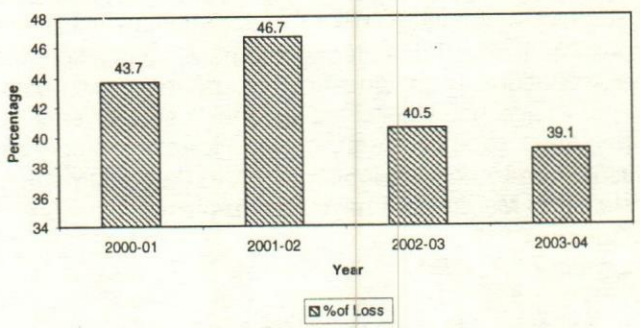


Fig. 2. Distribution Loss % of of Discoms

2001-02. However, the last FY experienced a slight decrease in the loss percentage from 46.7 in 2001-02 to 39.12 in 2003-04. SOUHCO reported the lowest average distribution loss followed by WESCO, CESCO, and NESCO during the period 2000-01 to 2003-04.

The huge loss can be attributed to large scale tampering of meters, bypassing of metered consumers and direct tapping from the LT audit overhead network. The Committee of Independent Experts appointed by the GoO to review the power sector reform in its report has brought to the fore very interesting causes of T&D losses, such as direct tapping of 11 KV feeder by industrial consumers, bypassing of meter CTs, unauthorized abstraction of energy by the illegal consumers, consuming energy far more in excess of what was shown in the consumer ledger of the Discoms etc. It indicates that there is a scope of diminution of distribution loss provided the companies take effective technical, financial and managerial decisions for reduction of distribution loss.

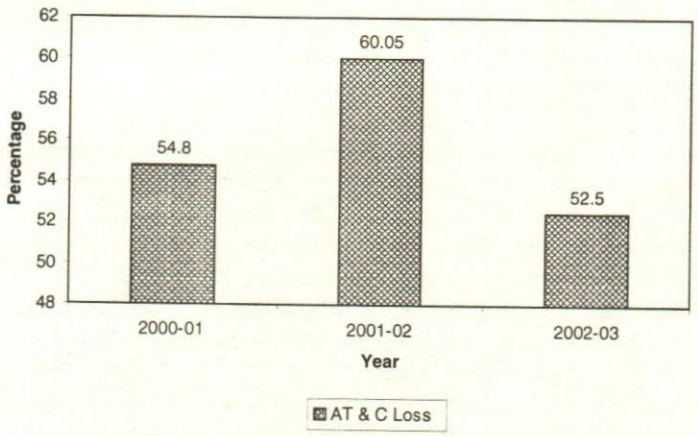


Fig. 3. AT & C Loss Percentage of Discoms

Administrative, Technical, and Commercial Loss (AT & C Loss)

The AT & C loss indicates the totality of loss owing to administrative, technical, and commercial losses such as non-billing, non-collection, theft etc. The AT & C loss levels of different Discoms are reported in Table 4 and Figure 3.

As the table evinces, like T&D loss percentage the AT&C loss percentage has slightly been reduced in the FY 2002-03 as compared to the FY 2001-02. Comparatively, WESCO incurred the lowest loss percentage and CESCO incurred the highest one. One of the reasons for increasing administrative costs over the years is the increasing employee cost. For instance, employee cost of NESCO during 1999-00 was Rs.9783.71, which increased to Rs. 10918.9 during the period 2003-04.

Table 4: AT & C Loss Percentage of Discoms

Year	CESCO (43.94)	NESCO (49.23)	WESCO (44.07)	SOUTHCO (43.9)	Avg. Loss
2000-01	58.7	51	56	53.7	54.8
2001-02	63.6	65	58	53.6	60.05
2002-03	55.9	53	48.12	50.9	52.5

Note: Figures in parentheses denote the targets set by the Commission.

Source: O.E.R.C, Bhubaneswar.

Table 5: Billing and Collection Efficiency of Discoms

Year	Discoms	Billed in (crores)	Collected in (crores)	Differences in (crores)	Percentage Collected
2000-01	C	584.37	437.89	146.48	75
	N	340.52	272.31	68.21	80
	W	466.88	364.1	102.78	78
	S	234.66	189.62	45.01	81
Average		406.6	315.98	90.62	78
2001-02	C	638.15	453.32	184.83	71
	N	317.37	227.36	90.01	72
	W	508.33	399.6	108.73	79
	S	263.93	205.89	58.04	78
Average		431.94	321.54	110.40	75
2002-03	C	666.92	45.01	140.63	79
	N	373.73	310.01	63.72	83
	W	626.26	526.49	99.77	84
	S	279.27	227.37	51.9	81
Average		486.54	277.22	89.01	81
2003-04	C	691.62	561.46	130.16	81
	N	395.74	355.86	39.88	90
	W	675.23	581.81	93.42	86
	S	287.81	242.22	45.59	84
Average		512.6	435.38	77.26	85

Note: Figures in Parentheses denote the target level of collection fixed by the Commission

Source: O.E.R.C, Bhubaneswar

Billing and Collection Efficiency

The billing and collection efficiency are two important parameters to measure the performance of a distribution company. Table 5 and Figure 4 presents a comparative picture of billing and collection efficiency of different Discoms.

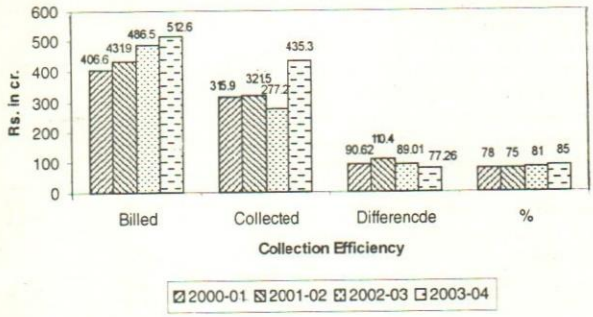


Fig. 4. Average Collection Efficiency of Discoms

The table and the figure denote that, though on an average the percentage of billing and collection efficiency of the four Discoms have increased slightly increased from 56.1% to 59.38 per cent and 78% to 85% respectively during the period in 2000-2001 to 2002-03, the distribution companies have failed to achieve the target collection level approved by the Commission. The Commission fixed a yardstick for collection efficiency: 85% for the year 2001-02 and 87.5% for the year 2002-03. The shortfall in revenue collection is mainly due to the receivables against energy charges from the various departments of the Government and State PSUs. More than Rs 230 crore has been piled up within a period of three years of operation of the Discoms since 01.04.1999.

It is also observed that the collection efficiency in respect of commercial category consumers (LT) is very poor, i.e., only 64% (SOUTHCO), 49% (WESCO), 64% (NESCO), and 62% (CESCO) for the FY 2002-03. The Commission has issued a direction to all the Discoms to launch special drives to improve collection efficiencies. As the tariffs of the commercial category is cost effective and their number are also very few, a full collection can be effected from LT consumers with minimum effort.

Consumers Covered

EHT, HT, and LT are three categories of consumers covered under the electricity sector. During the post-reform period, there has been a significant increase in the number of consumers for both HT and LT categories, as is revealed from Table 6.

Metering and Hooking Position

Twin strategies were adopted under the reform scheme for reduction of loss: (a) installation of working meters for all consumers to ensure proper energy accounting, billing and collection; (b) substantial capital outlay to strengthen the transmission and distribution system to eradicate the problems of technical inadequacy.

Table 6: No. of Consumers Covered under Discoms

Year	Category of Consumers	SOUTHCO	NESCO	WESCO	CESCO	Total
2000-2001	EHT	10	6	14	6	36
	HT	76	129	284	377	866
	LT	381,884	311,689	343,654	656,535	16,937,62
	Total	381,970	311,804	343,952	656,918	16,946,4
2001-2002	EHT	10	6	13	7	36
	HT	82	137	253	452	924
	LT	411,504	373,923	379,002	691,921	18,570,75
	Total	411,596	374,066	379,268	692,380	18,573,10
2002–2003	EHT	10	6	13	9	38
	HT	91	343	258	510	1202
	LT	423,779	398,381	405,018	748,209	19,753,79
	Total	423,880	398,730	405,289	748,728	19,766,27

Source: O.E.R.C, Bhubaneswar.

Though adequate funding was provided to Discoms, the overall result turned out to be very disappointing. Several technical deficiencies such as defective meters, rampant theft of electricity by unabated hooking (which is done even with the knowledge of the employees of the utilities), extensive practice of load factor billing etc. have resulted in huge commercial losses for the Discoms (Table 7).

After the formation of Discoms, the metering installation/requirement work was handed over to them. In the Financial Year (FY) 2000-01, the total number of meters in the State was 13,951,83 of which about 913,709 (65.5%) meters are working and 660,351 are defective meters. In the FY 2002-03, the total number of meters and working meters was increased by 17.72% and 7.15% respectively. However, the total number of defective meters detected and replaced was reduced by 0.02% and 0.12% correspondingly. During the FY 2003-04, CESCO had achieved 100% metering (the no. of consumers and meters during that year was 823880). During the financial year, 2000-01, 2002-03 (up to 31st January), the total number of hooks detected by the four Discoms was 4,48,135, of which only about 1,96,882 number of connections were regularised.

Electrification

Electrification level: Electrification level provides an estimation of the proportion of the population that has physical access to electricity. The electrification levels for the non-poor in Orissa increased from 47.60 % in 1999-2000 to 56.06 % in 2001-02, whereas electrification levels for the poor decreased from 3.67 % to 3.31 % in the same period. The reason for this could be extrication of installations because of payment default. Another reason could be due to the incentivisation of the private

Table 7: Metering and Hooking Position of Distribution Companies

Metering Position	SOUTHCO			CESCO			NESCO			WESCO		
	2000-01	01 -02	02- 03	2000-01	01 -02	02- 03	2000-01	01 -02	02- 03	2000-01	01 -02	02- 03
No. of Meters	3,56,173	3,83,106	3,99,216	5,24,557	5,60929	6,17,810	2,46,101	2,71,177	3,03,809	2,68,352	3,28,849	3,21,603
No. of Working	2,60,585	2,96,814	3,21,538	213,525	2,34,226	3,59,261	1,46,839	1,71,996	2,03,658	2,09,471	2,63,212	2,72,262
Meters %	73	77	81	41	42	58	60	63	67	78	80	84.6
No. DM	95,588	30, 006	11,917	3,11,032	3,26,703	2,58,549	99.262	98,181	100,151	58,881	45,637	49,341
Replacement of DM	18,343	-	55	35,172	15,646	27,320	30.306	3780	2318	28,727	20,753	4,559
New Meters Installed (3PH)	-	25,624	20,015	34,392	36,576	31,829	-	-	-	-	-	-
New Meters Installed (1PH)	17,714	-	15,114	81,720	59,241	14,4302	-	-	-	-	-	-
No. of Hooks Detected	1540	8,726	3739	19,158	27,528	42,023	-	-	79,820	224	225	51,823
No. of Connections Regularised	1540	8,726	203	-	370	3,683	8,423	38618	1,2505	224	225	34,173
Con.Prosecuted/ Initiated in Court	-	-	-	-	-	-	-	-	-	-	-	-

Note: '-' indicates nil. DM - Defective Meters

Source: O.E.R.C, Bhubaneswar

utility to try to minimize loss by discouraging new connections for the poor (Sihag, Misra, and Sharma, 2004).

Table 8: Tariff Rates for the Domestic and Commercial Consumers

Domestic		Commercial	
1st 100 unit	0.90 Paise per unit.	1st 100 unit	1.80 Paise per unit
Next - 101 to 200 units	1.20 Paise per unit	Next - 101 to 200 units	2.30 Paise per unit
Balance-201 and onwards	1.60 paise per unit	Balance-201 and onwards	2.40 Paise per unit
1st February 2001 and still continuing			
1st 100 unit	1.40 paise per unit	1st 100 unit	3.20 paise per unit
Next- 101 to 200 units	2.30 paise per unit	Next- 101 to 200 units	4.10 paise per unit
Balance-201 and onwards	3.20 paise per unit	Balance-201 and onwards	4.50 paise per unit

Source: O.E.R.C, Bhubaneswar

Electrification rates: The electrification rate measures the pace of electrification. This indicator is used to determine the extent to which the reform option accelerates access to electricity, especially among the poor. The electrification rates for the poor in Orissa have gone down drastically during the post-reforms period (1999-2000). With the advent of the reform process, electrification rates for the non-poor households in Orissa increased from 7.7% in the year 1998-99 to 9% in the year 2001-02. The reasons for the de-electrification of the poor consumer could be that many of them opted out because of relatively higher charges (Sihag, Misra, and Sharma, 2004).

Electricity consumption: The electricity consumption per household for the poor households Orissa shows a sharp decline of 41% between 1998-99 and 2002-03.

Electricity tariff: The average tariff rate has increased at a cumulative annual growth rate of 15.54 per cent. Tariff revisions have been made by the Commission five times and the sixth one is pending for implementation. The frequent tariff revision has caused dissatisfaction both among the domestic and commercial consumers. Table 8 denotes the present tariff rates for the domestic and commercial consumers in the State.

Rural electrification (RE): During the pre-reform period i.e, up to 31.03.1995, out of 46,992 census villages in Orissa, 35,903 villages were electrified. It registered coverage of 76.40% of the total villages in the State and extending to the benefits of electricity to about 89.0% of the rural population (O.S.E.B, Annual Administration Report, 1994-1995). After privatisation of electricity distribution, the rural electrification wing was separated, and the focus on rural electrification was lost. A comparison of the rural electrification in Orissa during the pre and post-reform period has been made in

Table 9: RE during the Pre and Post Privatisation Period

Time Period	Name of the Company	Village Electrification		Pump Set Energisation			Kutir Jyoti Connection	Discrepancy	
		No. of inhabited Villages	Achieve-ments	OLIC	No. of Villages	Achieve-ments		No. of Villages	Achieve-ments
Upto 31.03.1995	O.S.E.B	46,992	35,903 (76.4)	14,993	51,931	66,924	8429	N.A.	N.A.
Upto 28.02.2001	CESCO	11,609	10,290 (88.6)	48,147	13,023	17,870	22077	107	15 (14.0)
	NESCO	11,142	9030 (81.04)	5891	11,599	17,490	25078	88	20 (22.7)
	WESCO	10,423	8036 (77.0)	2527	22,514	25,041	28917	152	10 (6.5)
	SOUTHCO	13,733	7876 (57.3)	3645	10,579	14,224	27619	155	3 (1.9)
	Total	93,899	71,135	31,903	10,96,46	14,1594	11,21,20	502	48

Note: 1.'NA'- indicates data not available 2. Figures in parenthesis indicates percentage

Source: O.E.R.C, Bhubaneswar

Table 9. As the table indicates, there has been no significant improvement in RE during the post-reform period except under the Kutir Jyoti programme, where single point power supply has been given to nearly 1,03,691 households belonging to the weaker section of the society.

Table 10: Ranking of States by ICRA and CRISIL

State	2004 Points (Ranks)	2003 Points (Rank)
Delhi	57.00 (1)	52.50 (6)
Andhra Pradesh	56.75 (2)	71.50 (1)
Goa	52.20 (3)	41.68 (12)
Karnataka	5 1.25 (4)	68.00 (2)
Gujarat	50.99 (5)	51.43 (7)
Haryana	49.63 (6)	64.00 (3)
Punjab	46.00 (7)	45.00 (10)
Himachal Pradesh	44.16 (8)	49.38 (8)
Uttar Pradesh	41.85 (9)	42.83 (11)
Rajasthan	41.83 (10)	64.00 (4)
Maharashtra	37.75 (13)	60.00 (5)
Orissa	20.31 (19)	33.00 (14)

Source: Adapted from PRAYAS , 2004.

MoP/PFC had commissioned a study of all the states on reform-related aspects, which was made by ICRA and CRISIL. Each of the 28 states initiating reform process had been given marks out of 100 based on the following parameters: external (state government and RC), internal (business risk analysis and financial risk analysis), progress on attaining commercial viability and others (status of information systems etc). Table 10 captures scores of the top few states including the state of Orissa. It can be seen that Delhi tops the list with 57 points, followed by AP and Goa, whereas points for Orissa are very low both for the years 2003 and 2004, and it ranks middling.

Benefits of Privatisation of Distribution

Despite the poor performance, there are some indications of improvement in the quality of services. Anecdotal evidence on the quality of service in the post-privatization period is given in various *GRID Corporation of Orissa Newsletters* between the periods May-Dec 2002. The distribution companies have been successful in restoring supply within 24 hours of reporting of fault for close to 100% of the cases, when the minimum standard prescribed by O.E.R.C was 80%. Likewise, while the Discoms are expected to provide new connections to domestic consumers within 40 working days of applications in 85% of the cases, the actual achievement is greater than 98% by all distribution licensees.

Lessons from the Orissa Experience

Restructuring and privatization are two key features of the Orissa power sector reform: Restructuring aimed at the unbundling generation, transmission and distribution function of the former O.S.E.B, privatization of distribution system, on the other hand, aimed at introducing an effective private management for investment and raising revenues for the government, improving efficiency, inducing competition in the power sector, providing better services to the consumers and the society at large.

Conversely, as the above analysis divulges, privatization of electricity distribution has failed to accomplish the objectives for which it was initiated in the state. It has failed to generate palpable improvement in the financial position, billing and collection efficiency, regularization of unauthorized meter and hooking position, reduction in T & D and AT & C loss percentage and rural electrification level in the state.

Other states from the reform experience of Orissa can emulate the following lessons:

- Once the Government takes a policy decision in favour of privatisation, it should adopt a fast track or rapid privatisation approach.
- The failure of DOA due to continued Government meddling entails that the Management Contract Approach is more appropriate for the Indian environment.
- One of the foremost objectives of the reform was to introduce competition in the power sector. In Orissa, though 51 companies/consortia participated in the international bidding, only 13 companies/consortia submitted their SoQs and 1 bidder was selected for three Discoms. The highest dropout rate happened among the International bidders. This ought to be a source of concern for all Governments implicated for the privatization. Without large-scale participation of international bidders, it possibly will not be feasible to boost the competition level considerably, which may also lead to the breakdown of privatisation.
- The private players must bring in superior management skills.

To improve the operational efficiency of the electricity distribution system, the following measures can be taken by the Discoms:

- Effective management of time schedules, billing counters/mobile counters to be deployed in the commercial areas as per the business requirements.
- The distribution companies have to bolster their machinery for improving collection of revenue for which they need state government support for law and order issue.
- Regular media coverage about the activities/awareness about the laws of the electricity in classified columns of daily local newspapers/so also communication thereof in cable TV should be made with due consideration of its cost effectiveness.
- IT system inside thn companies should be futher developed.
- Consumer redressal/customer care to be more effective.
- Legal cells should be activated so that specific consumers cases can be dealt expeditiously.
- Energy audit teams should be given more importance.
- Quality circles and suggestion schemes, which have almost become defunct in many Discoms, must be revived.
- Leadership quality, team spirit must be rejuvenated among the employees.
- Motivational schemes like incentives for achieving the target, formal appreciation, reward and recognition, individual and team-based reward etc. must be devised and implemented.
- Monthly interactions with the staff/workers with engineers (Managers) must be encouraged to sort out the odd ends.
- Special provisions must be made to embark upon the electricity needs of the large poor population of the state.
- Rural electrification ought to be accelerated.

References

Baijal (1999), "Restructuring Power Sector in India", EPW Special Articles, 25 September.

GoO (2001), "Report of the Kanungo Committee on Power Sector Reforms inn Orissa", Bhubaneswar.

Ministry of Power (GoI) (2002), "Indian Power Sector–A Profile", http://www.worldenergy.org/wec-geis/global/downloads/India Power.pdf.

Prayas (2004), "India Power Reforms Update", Issue VIII, May.

Sihag A.R., Misra N. and Sharma V. (2004), "Energy for Sustainable Development", Volume VIII, No. 4, December.

World Bank (2000), "State Power Sector Reform–A Review of the Orissa Expertise", Draft Final Report, Frontier Economics, April. □

Feature

Relative Rating Model for Justification of Competitive Supply Chain

Rambabu Kodali & Srikanta Routroy

To strengthen the position in today's highly competitive and fast-paced business environment, organizations should adopt inter-organizational relationships through competitive supply chain. The perceptible impact of the competitive supply chain lies in attaining far-reaching world-class standards. The present work describes a multi-attribute decision model using relative rating model for justification of competitive supply chain.

Rambabu Kodali and Srikanta Routroy are from Birla Institute of Technology & Science, Pilani, Rajasthan.

In today's marketplace, organizations are looking for ways to differentiate themselves from their competitors. Creating competitive advantage is vital to sustaining growth. Companies are aggressively pursuing initiatives to better manage their supply chains, including expanding the scope of management of their operations to manage upstream and downstream channels.

Investment in information technology (IT) for managing supply chains has been an effective way of obtaining competitive advantage (Spalding, 1998; Kwan, 1999). IT consists of the hardware and software throughout a supply chain that not only gathers but also analyses and acts on information. IT in general and more specifically IT in supply chain management (SCM) can lead to great opportunities, ranging from direct operational benefits to the creation of strategic advantage. For example Mcfarlan (1984), Benjamin et. al. (1985), and Porter and Millar (1985) argued already in the 1980s for the strategic possibilities of IT for business. Porter and Millar in particular advocate that IT changes industry structures and rules of competition, creates competitive advantage, and creates new business opportunities. In the logistics/supply chain context, Bowersox and Daugherty (1995) outlined that IT is the key to companies creating a strategic advantage by enabling centralized strategic planning with day-to-day centralized operations.

A common view is that IT has a profound impact on managing supply chains. Using case studies in six Finnish industrial supply chains as data, Kemppainen and Vepsäläinen (2003) argued that IT is, alongside specialization and outsourcing, a key precondition for networking of organizations. One group of scholars argued that because of information technologies, supply chains become less integrated and more market oriented (Malone et. al., 1987; Golicic et. al., 2002; Williams et. al., 2002). For example, Williams et al. suggested that electronic SCM combines the structural benefits of SCM with the efficiency benefits

of arms length approach, enabling, for example, lower cost through possibilities of selecting from a larger supplier base. With the emergence of the Internet and other wide area networks, the technological basis for connecting a firm's internal IT with outside computer networks is created. Shared IT is often used between suppliers and customers, but sometimes also involves competing organizations, research institutions or consultancies.

Internal IT

The category of internal IT encompasses all information systems that are only used within organizational boundaries. These systems can support the entire organization, or specific task functions within the organization. Applications that are basically used inside the organization are office automation, transaction processing systems, enterprise resource planning systems, data warehousing systems, groupware applications, intranets, and executive information systems. Table 1 illustrates the major benefits and different types of internal IT applications (Ryssel, Ritter and Georg, 2004).

Table 1: Applications of internal IT and their benefits

Applications of internal IT	Benefits
Office automation	• Reduction of processing time
	• Improvement of quality
	• Reduction of time-consuming routine work
Transaction processing	• Reduction of overheads
	• Faster response to customer demands
Enterprise resource planning	• Business process reengineering
	• Reduction of cost
	• Improvement of customer service
Data warehousing	• Improved customer care
	• Better planning of future developments
Groupware	• Improved flow of information
	• Reduction of redundant work
	• Improvement of work-quality
Intranets	• Provide additional organization-intern services
	• Improved flow of information
	• Better customer service
Executive information	• Improved strategic planning
	• Executive decision-making support
	• Improvement of customer orientation

Shared IT

None of today's corporations exist as isolated entities. Companies are part of a marketplace where different types of organizations come together and exchange information, services and goods. Shared IT relates to computer and communication technology, which supports doing business between a corporation and organizations outside its boundaries (Jonston and Vitale, 1988). These organizations can be geographically dispersed and utilize modern network technology. The shared use of IT helps to support an organization's interactions with other organizations, i.e. buyers and sellers (Applegate et al., 1996). Inter-organizational systems, electronic data interchange (EDI) and extranets are the most popular shared IT tools. Table 2 shows these applications of shared IT and the benefits to an organization engaging in these technologies (Ryssel, Ritter and Georg, 2004).

Table 2: Applications of shared IT and their benefits

Applications of shared IT	Benefits
Inter-organizational systems	• Reduction of transaction costs
	• Increased customer responsiveness
	• Increase efficiency
	• Differentiated products and services
	• Increased bargaining power
Electronic data interchange	• Reduction of costs for order processing
	• Reduction of inventory and inventory costs
	• Elimination of labour-intensive tasks
	• Enhanced communication
Extranets	• Strengthens closeness between participating organizations
	• Reduction of operational costs
	• Enhanced communication
	• Reduction of cooperation costs

Types of supply chains

Supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of ultimate customers. On the basis of the communication strategy, the supply chains can be classified into three types i.e. traditional supply chain (push

process), e-supply chain (pull process) and competitive supply chain (push and pull).

Traditional supply chain: This is a serial supply chain that existed until the pre-internet solution. All supply chain processes can be broken into the following four process cycles i.e. customer order cycle, replenishment cycle, manufacturing cycle and procurement cycle. Therefore, it has five stages i.e. customer, retailer, distributor, manufacturer and supplier. The benefits of the traditional supply chain are as follows:

- Decreases inventory costs by more accurately predicting demand and scheduling production to match it
- Reduces overall production costs by streamlining the flow of goods through the production process and by improving information flow between an enterprise, its suppliers and distributors.
- Improves the customer satisfaction by offering better quality, higher product variety and fast response.

E-supply chain: The latest generation of supply chain management is web centric. It is characterized by the marriage of the internet and supply chain and has resulted in the birth of the e-supply chain. These internet enabled e-supply chain applications have integrated all branches of the supply chain and emerged as the most effective means of supply chain operation. E-supply chain (i.e. e-procurement, e-commerce and e-collaboration) can change the supply chain from a linear and rigid chain into a dynamic chain. E-procurement, e-commerce and e-collaboration are discussed below.

E-commerce: It refers generally to all forms of transaction involving both organizations and individuals that are based upon the electronic processing and transmission of data, including text, sound and visual images.

E-procurement: The procurement process is that process by which a manufacturer procures products from suppliers. Internet procurement solutions automate all steps of procurement process. Now, instead of only dealing with local and large parts dealers, manufacturers and suppliers have access to a competitive, global market via the internet and e-procurement applications. Many more players are brought into the supply chain, but all that they have to offer is consolidated into a single database, linked to the rest of the chain by the information hub.

E-collaboration: It is simply information sharing, collaborative planning and collaborative product development. The information hub stores quantitative information and it can also serve as a platform for information sharing between supply partners. Everything from purchase orders, sales order, invoices, cheques and other business documents may be shared over the internet. Collaborative planning provides a means for implementing group decision-making in a cost effective way, because it considers every part of the chain. Enterprises across the chain can effectively exchange all necessary knowledge to make wise decisions for the whole chain. Essentially, e-collaboration technology allows real time sharing of product sales forecasts, replenishment plans and as a result it can closely match supply and demand across the whole chain. Ultimately, the collaborators can jointly reduce inventory costs and customer service levels.

Some of the benefits of e-supply chain are as follows:

- Increase the speed and accuracy with which businesses can exchange information, thereby reducing costs and errors in transactions.
- Help in speed notification of product design changes and adjustments.
- Electronic order tracking
- Ease in determining customer demand fluctuations
- Ease in making a customer satisfaction survey
- Recording useful performance data about the supply chain
- Ease in identification of new supplier
- Compare potential suppliers quickly on a wide variety of criteria such as quality, price and delivery.
- Run 24/7 (i.e. 24 hours in a day and seven days in week)

Some of the potential disadvantages of the e-supply chain are as follows:

- The cost and benefit are hard to quantify.
- It requires highly educated software professionals who may be difficult to find, recruit, develop and retain.
- The cost of entry into some e-commerce reengineered supply chains may eliminate or limit small companies or limit small companies who otherwise could be very good suppliers.

- Resistance to change may be high. Employees, customers and suppliers who are familiar with traditional business, may have difficulty with the required technology.

Competitive supply chain: Over the past few years, the combination of economic, technology and market forces have compelled companies to examine and rethink supply chain strategies. Some of these forces include the globalization of business, proliferation of product variety, increasing complexity of supply chain networks and the shortening of the product life cycles. To stay competitive, enlightened companies have strived to achieve greater coordination and collaboration among supply chain partners, in an approach called "competitive supply chain". It is the integration of the traditional supply chain and the e-supply chain, which offers the benefits of traditional supply chain and e-supply chain. The architecture of competitive supply chain is shown in the figure 1. The benefits of competitive supply chain are:

- Good response to customer requests
- Increase in on-time delivery
- Reduction in order fulfilment lead time
- Increase in customer satisfaction and relations
- Increase in ability handle unexpected challenges
- Reduction in inventory
- Low cost of purchased items
- Reduction in overall cost
- Increase in overall productivity
- Increase in overall product quality
- Ease in market penetration
- Reduction in product innovation lead-time
- Reduction in cost of new product development
- Reduction in logistics cost
- Increase in share price/ shareholder value
- Increase in revenue growth
- Increase in profitability

Development of relative rating model for justification of competitive supply chain

In the modelling approach to decision making, a major problem consists in the scaling of judgement. This is, in general, the true situation in most decision-making cases involving the evaluation of non-measurable attributes. This is also the situation when the attribute performances could be measured, but no measurable definitions of them are available prior to the selection process. In those cases, in order to select the best alternative, it is necessary to resort to the design of scales of judgement to weigh the rating importance of one attribute over the others. Therefore, relative rating model is developed for justification competitive supply chain. Relative rating model enables the decision-maker to represent the simultaneous interaction of many factors in a complex, unstructured situation. A highly user-friendly computer model is developed which assists the user in evaluating his/her choices. A thorough analysis of the problem is required along with the identification of the important attributes involved. The selection of the attributes has been determined through literature survey and discussions held with experts. The attributes and sub-attributes used in the relative rating model for justification of competitive supply chain are as follows:

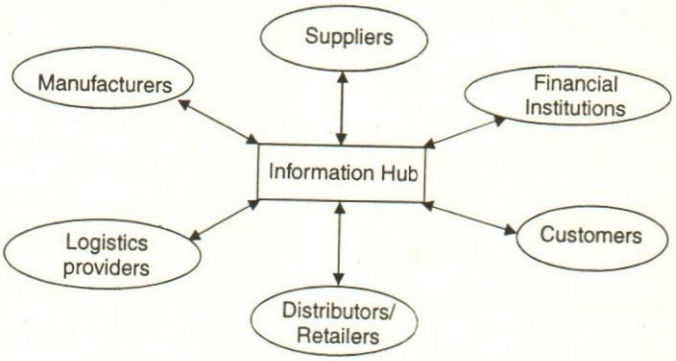


Fig. 1. Architecture of competitive supply chain

Suppliers	[SUP]
Involvement in design	[IND]
Delivery and quantity commitment	[DQC]
Quality and price commitment	[QPC]
Flexible	[FLX]
Policies and regulations	[PAR]
Relationship	[REP]
Continuous improvement commitment	[CIC]
Manufacturing and management procedures/methods	[MMP]
Proximity	[PRX]
Outsourcing/subcontracting	[OUS]
Manufacturers	[MAR]
Facilities/Resources	[FAR]

Flexibility	[FLY]
Innovative product planning	[IPP]
Level of automation	[LOA]
Manufacturing methods	[MAM]
Capacity	[CAP]
Management procedures	[MAP]
Mode/layout styles	[MLY]
Outsourcing	[OUT]
Organizational	[ORG]
Organization levels and structure	[OLS]
Growth orientation	[GRO]
Vigilance	[VIL]
Commitment to technology	[CTT]
Acceptance of risk	[ACR]
Cross functional co-operation/co-ordination	[CFC]
Receptivity	[REP]
Slack	[SLA]
Adaptability	[ADA]
Diverse and committed workforce	[DCW]
Distributors/ Retailers	[DIR]
Order processing logistics	[OPL]
Warehousing logistics	[WAL]
Transportation logistics	[TRL]
Information logistics	[INL]
Inventory logistics	[IVL]
Coordination and synchronization logistics	[CSL]
Logistics providers	[LOP]
Cost efficient logistics	[COE]
Time efficient logistics	[TEL]
On time delivery logistics	[ODL]
Flexible logistics	[FLL]
Range of services	[ROS]
Reliable handling logistics	[RHL]
World wide network	[WWN]
Adoption of communications technology	[ACT]
Real-time tracking	[RTT]
Customers	[CUS]
Ordering ease	[ORE]
Delivery	[DEL]
Value added services	[VAS]
Service charges	[SEC]
Customer consulting	[CUC]
Installation	[INS]
Customer training	[CUT]
Better trained service personnel	[BTP]
Maintenance and repair	[MAR]
Customer feedback	[CUF]
Marketing	[MKG]
Market demand	[MAD]
Market environment	[MAE]
Market segments and targets	[MST]
Markets and buying behaviour	[MBB]
Market competitors	[MRC]
Marketing strategies	[MAS]
Type of marketing	[TOM]
Marketing programmes and logistics	[MPL]
Evaluation of market activities	[EMA]
Financial	[FIN]
Capital outlay	[CAO]
Sources of capital	[SOC]
Production cost	[PRC]
Infrastructure cost	[INC]
Transportation cost	[TRC]
Working capital	[WOC]
Overheads and expenses	[OVE]
Cash flow projections	[CFP]
Competitive position	[COP]
Improvement in forecasting	[IIF]

Table 3: Case situation

Industry type	Process
Production volume	High
Company vision	Star performer and market leader
Mission	Continuous improvement of product processes and people

Table 4: Weightages of attributes for alternatives

Attri.	Sub-attri	Weightage		Normalized weightage		Net Weightage	Weightage for alternatives			Desirability Index		
		Attri.	Sub-attri	Attri.	Sub-attri		TSC	ESC	CSC	TSC	ESC	CSC
		10		0.1								
	IND		11		0.11	0.011	10	45	45	0.11	0.495	0.495
	DQC		14		0.14	0.014	10	30	60	0.14	0.42	0.84
	QPC		12		0.12	0.012	30	20	50	0.36	0.24	0.6
SUP	FLX		12		0.12	0.012	20	30	50	0.24	0.36	0.6
	PAR		9		0.09	0.009	10	10	80	0.09	0.09	0.72
	REP		11		0.11	0.011	20	30	50	0.22	0.33	0.55
	CIC		9		0.09	0.009	25	25	50	0.225	0.225	0.45
	MMP		8		0.08	0.008	20	30	50	0.16	0.24	0.4
	PRX		7		0.07	0.007	60	10	30	0.42	0.07	0.21
	OUS		7		0.07	0.007	10	45	45	0.07	0.315	0.315
										0.2035	0.2785	0.518
		10		0.1								
	FAR		12		0.12	0.012	20	50	30	0.24	0.6	0.36
	FLY		12		0.12	0.012	10	30	60	0.12	0.36	0.72
	IPP		12		0.12	0.012	30	20	50	0.36	0.24	0.6
	LOA		15		0.15	0.015	20	50	30	0.3	0.75	0.45
MAR	MAM		12		0.12	0.012	30	20	50	0.36	0.24	0.6
	CAP		10		0.1	0.01	10	40	50	0.1	0.4	0.5
	MAP		9		0.09	0.009	40	30	30	0.36	0.27	0.27
	MLY		8		0.08	0.008	30	30	40	0.24	0.24	0.32
	OUT		10		0.1	0.01	10	40	50	0.1	0.4	0.5
										0.242	0.389	0.424
		12		0.1								
	OLS		7		0.07	0.0084	20	30	50	0.168	0.252	0.42
	GRO		10		0.1	0.012	10	30	60	0.12	0.36	0.72
	VIL		15		0.15	0.018	15	25	60	0.27	0.45	1.08
	CTT		15		0.15	0.018	20	25	55	0.36	0.45	0.99
ORG	ACR		12		0.12	0.0144	20	30	50	0.288	0.432	0.72
	CFC		15		0.15	0.018	10	30	60	0.18	0.54	1.08
	REP		6		0.06	0.0072	10	20	70	0.072	0.144	0.504
	SLA		6		0.06	0.0072	15	35	50	0.108	0.252	0.36
	ADA		6		0.06	0.0072	20	20	60	0.144	0.144	0.432
	DCW		8		0.08	0.0096	15	25	60	0.144	0.24	0.576
										0.1854	0.3264	0.6882
		8		0.1								
DIR	OPL		20		0.2	0.016	15	25	60	0.24	0.4	0.96
	WAL		14		0.14	0.0112	10	45	45	0.112	0.504	0.504
	TRL		16		0.16	0.0128	20	20	60	0.256	0.256	0.768
	INL		16		0.16	0.0128	20	20	60	0.256	0.256	0.768
	IVL		14		0.14	0.0112	10	40	50	0.112	0.448	0.56
	CSL		20		0.2	0.016	15	35	50	0.24	0.56	0.8
										0.203	0.404	0.726

(Contd...)

(Table 4 Contd.)

Attri.	Subattri	Weightage		Normalized weightage		Net Weightage	Weightage for alternatives			Desirability Index		
		Attri.	Sub-attri	Attri.	Sub-attri		TSC	ESC	CSC	TSC	ESC	CSC
		11		0.1								
	COE		14		0.14	0.0154	20	30	50	0.308	0.462	0.77
	TEL		14		0.14	0.0154	20	30	50	0.308	0.462	0.77
	ODL		9		0.09	0.0099	10	40	50	0.099	0.396	0.495
	FLL		12		0.12	0.0132	10	40	50	0.132	0.528	0.66
LOP	ROS		9		0.09	0.0099	15	25	60	0.149	0.248	0.594
	RHL		14		0.14	0.0154	35	30	35	0.539	0.462	0.539
	WWN	23	9		0.07	0.0077	20	30	50	0.154	0.231	0.385
	ACT		7		0.07	0.0077	20	40	40	0.154	0.308	0.308
	RTT		12		0.12	0.0132	15	40	45	0.198	0.528	0.594
										0.2268	0.403	0.568
		12		0.1								
	ORE		6		0.06	0.0072	25	25	50	0.18	0.18	0.36
	DEL		9		0.09	0.0108	20	20	60	0.216	0.216	0.648
	VAS		12		0.12	0.0144	15	35	50	0.216	0.504	0.72
	SEC		11		0.11	0.0132	20	35	45	0.264	0.462	0.594
CUS	CUC		12		0.12	0.0144	10	45	45	0.144	0.648	0.648
	INS		7		0.07	0.0084	15	25	60	0.126	0.21	0.504
	CUT		7		0.07	0.0084	15	25	60	0.126	0.21	0.504
	BTP		14		0.14	0.0168	20	35	45	0.336	0.588	0.756
	MAR		12		0.12	0.0144	20	35	45	0.288	0.504	0.648
	CUF		10		0.1	0.012	20	35	45	0.24	0.42	0.54
										0.2136	0.3942	0.5922
		12		0.1								
	MAD		15		0.15	0.018	15	30	55	0.27	0.54	0.99
	MAE		12		0.12	0.0144	25	35	40	0.36	0.504	0.576
	MST		14		0.14	0.0168	30	35	35	0.504	0.588	0.588
	MBB		9		0.09	0.0108	25	50	25	0.27	0.54	0.27
MKG	MRC		8		0.08	0.0096	20	40	40	0.192	0.384	0.384
	MAS		12		0.12	0.0144	20	30	50	0.288	0.432	0.72
	TOM		7		0.07	0.0084	40	30	30	0.336	0.252	0.252
	MPL		9		0.09	0.0108	30	40	30	0.324	0.432	0.324
	EMA		14		0.14	0.0168	20	50	30	0.336	0.84	0.504
										0.32	0.501	0.512
		9		0.1								
	CAO		10		0.1	0.009	30	40	30	0.27	0.36	0.27
	SOC		10		0.1	0.009	10	45	45	0.09	0.405	0.405
	PRC		15		0.15	0.0135	25	40	35	0.338	0.54	0.4725
	INC		15		0.15	0.0135	50	20	30	0.675	0.27	0.405
FIN	TRC		16		0.16	0.0144	50	20	30	0.72	0.288	0.432
	WOC		14		0.14	0.0126	30	35	35	0.378	0.441	0.441
	OVE		10		0.1	0.009	15	40	45	0.135	0.36	0.405
	CFP		10		0.1	0.009	30	35	35	0.27	0.315	0.315
										0.3595	0.3724	0.3932

(Contd...)

(Table 4 Contd.)

Attri.	Subattri	Weightage		Normalized weightage		Net Weightage	Weightage for alternatives			Desirability Index		
		Attri.	Sub-attri	Attri.	Sub-attri		TSC	ESC	CSC	TSC	ESC	CSC
		9		0.1								
	CAO		10		0.1	0.009	30	40	30	0.27	0.36	0.27
	SOC		10		0.1	0.009	10	45	45	0.09	0.405	0.405
	PRC		15		0.15	0.0135	25	40	35	0.338	0.54	0.4725
FIN	INC		15		0.15	0.0135	50	20	30	0.675	0.27	0.405
	TRC		16		0.16	0.0144	50	20	30	0.72	0.288	0.432
	WOC		14		0.14	0.0126	30	35	35	0.378	0.441	0.441
	OVE		10		0.1	0.009	15	40	45	0.135	0.36	0.405
	CFP		10		0.1	0.009	30	35	35	0.27	0.315	0.315
										0.3595	0.3724	0.3932
		16		0.2								
	IIF		7		0.07	0.0112	10	40	50	0.112	0.448	0.56
	IIP		7		0.07	0.0112	15	35	50	0.168	0.392	0.56
	IIQ		10		0.1	0.016	25	40	35	0.4	0.64	0.56
COP	IPM		10		0.1	0.016	40	30	30	0.64	0.48	0.48
	ICS		15		0.15	0.024	30	30	40	0.72	0.72	0.96
	ECR		15		0.15	0.024	10	40	50	0.24	0.96	1.2
	RIN		15		0.15	0.024	10	40	50	0.24	0.96	1.2
	RIL		6		0.06	0.0096	10	40	50	0.096	0.384	0.48
	RIC		15		0.15	0.024	20	35	45	0.48	0.84	1.08
										0.344	0.6471	0.7867
									TOTAL	**2.2978**	3.7156	5.2083

Improvement in productivity [IIP]

Improvement in quality [IIQ]

Improvement in profit margin [IPM]

Improvement in coordination and synchronization [ICS]

Enhancement in customer relations [ECR]

Reduction in inventory [RIN

Reduction in lead-time [RIL]

Reduction in cost [RIC]

The alternative supply chains are: traditional supply chain, e-supply chain and competitive supply chain. These alternatives are evaluated and compared in the light of the set of attributes and sub-attributes discussed above.

Traditional supply chain [TSC]

E-supply chain [ESC]

Competitive supply chain [CSC]

Algorithm of relative rating model

The steps to follow in using the relative rating model:

Step 1. Define the problem and determine the objective.

Step 2. Identify the alternatives available.

Step 3. Determine the main attributes/criteria and sub-attributes/criteria in each main attribute/criterion that govern the problem.

Step 4. All sub-attributes/ criteria are said to be the lowest level nodes and all main attributes/criteria are to be the top level nodes. If a main attribute/criterion does not have sub-attributes then the main attribute/criterion becomes the lowest level node.

Step 5. Assign the weightages to main attributes/criteria according to the relative rating. Relative Rating: a relative numerical weight is allocated directly to each attribute, such that the total sums add up to an agreed (normalized) value.

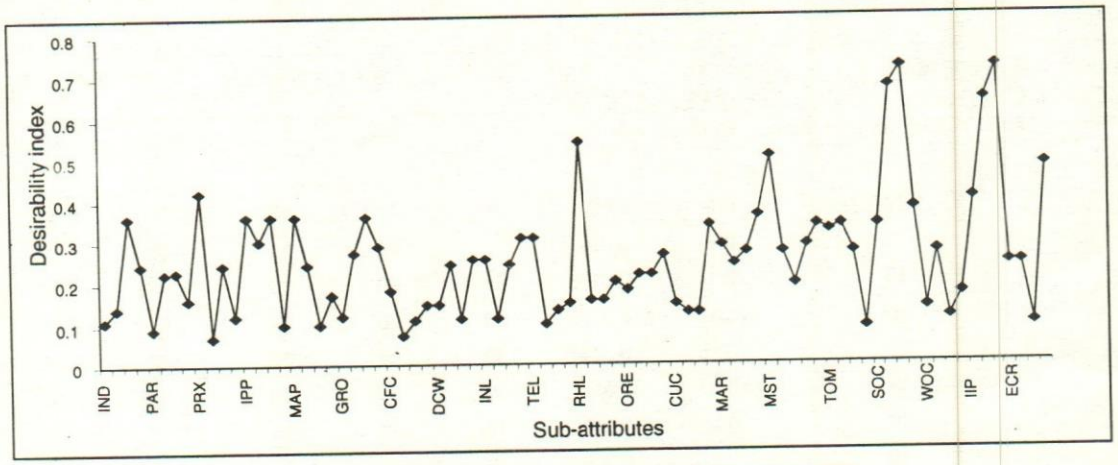


Fig. 2. Desirability index for sub-attributes of alternative: TSC

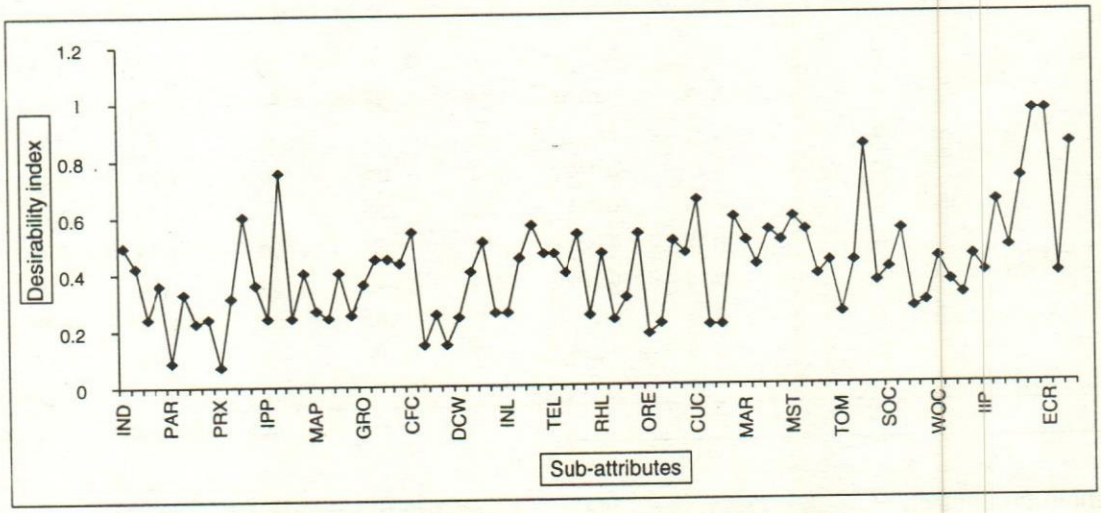


Fig. 3. Desirability index for sub-attributes of alternative: ESC

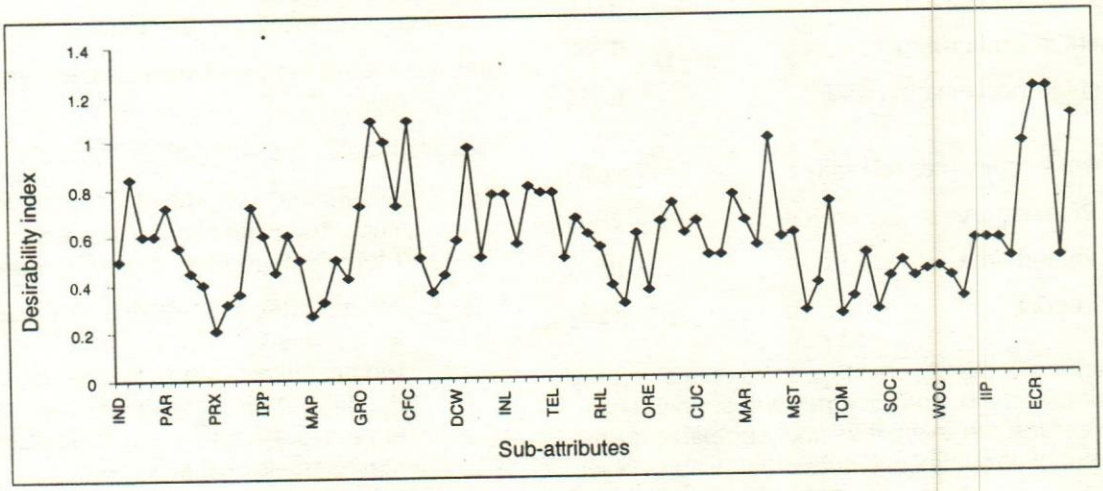


Fig. 4. Desirability index for sub-attributes of alternative: CSC

Step 6. Similarly assign weightages to the sub-attributes/criteria in each main attribute/criterion. The weightages are normalized.

Step 7. Consider each attribute/criterion of the lowest level node in turn and assign a weightage (relative rating) for each alternative.

Step 8. Evaluate net weightage as follows:
If the main attribute/criterion is the lowest level node, then the net weightage is the weightage of the main criterion/attribute. If sub-attribute/criteria is the lowest level node, then the net weightage is the product of weightage of the sub-attribute/criteria with the weightage of corresponding main attribute/criterion.

Step 9. Evaluate the 'Desirability Index' for each alternative as follows:

$$\text{Desirability Index for each alternative} = \frac{\sum_{\text{all lowest level nodes}} \text{Net weightage} \times \text{weightage for alternative}}{\text{number of lowest level nodes}}$$

Step 10. Select the alternative with the highest desirability index.

Validation of the model

The relative rating model is evaluated by the empirical approach. The approach is to test a representative set of selected test problems. For use in this problem, the focus is developed. In this case, it is to determine the justification of competitive supply chain. The attributes are compared with each other in a relative rating for a case situation (see table 3). From the analysis, it is clear that the competitive supply chain is the best option (see tables 4 and table 5). Highly user-friendly software: the relative rating model is developed in VC++ language to aid the user compare the attributes as well as the alternatives and for analysing the user inputs. The reliability of the judgements supplied by the user can be estimated from the graph (figure 2 to 5) that is generated for each alternative and its corresponding deciding criteria.

Table 5: Decision index for desirability of each alternative

Traditional supply chain	TSC	2.2978
E- supply chain	ESC	3.7156
Competitive supply chain	CSC	5.2083

Conclusion

The competitive supply chain has proved to be more promising and challenging compared to the traditional supply chain and e-supply chain. Relative rating model is used for the justification of competitive supply chain and to confer the adequacy of competitive supply chain implementation. One case study is elucidated in order to reinforce the salient features of the concept.

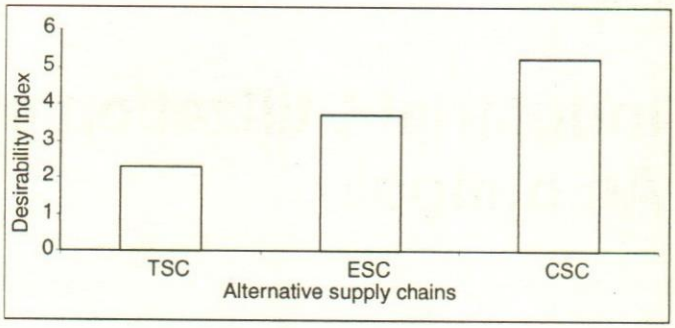


Fig. 5. Comparison of alternative supply chains

The obtained results are quite significant and promising.

References

Applegate, L., Holsapple, C. W., Kalakota, R., Rademacher, F. J. and Whinston, A. B. (1996), "Electronic commerce: building-blocks of new business opportunity", Journal of Organization Computing and Electronic Commerce, vol. 6, no. 1, pp. 1-10.

Benjamin, R. I., Rockart, J. F., Scott Morton, M. S. and Wyman, J. (1985), "Information technology: a strategic opportunity", Sloan Management Review, vol. 25, no. 3, pp. 3-10.

Bowersox, D. J. and Daugherty, P. J. (1995), "Logistics paradigms: the impact of information technology", Journal of Business Logistics, vol. 16, no. 1, pp. 65-80.

Golicic, S. L., Davis, D. F., Mccarthy, T. M. and Mentzer, J. T. (2002), "The impact of e-commerce on supply chain relationships", International Journal of Physical Distribution and Logistics Management, vol. 32, no. 10, pp. 851-87.

Jonston, H. R. and Vitale, M. R. (1988), "Creating competitive advantage with inter-organizational systems", MIS Quarterly, vol. 12, no. 2, pp. 153-165.

Kemppainen, K. and Vepsäläinen, A. P. J. (2003), "Trends in industrial supply chains and networks", International Journal of Physical Distribution and Logistics Management, vol. 33, no. 8, pp. 70.

Kwan, A. T. E. (1999), "The use of information technology to enhance supply chain management in the electronics and chemical industries", Production and Inventory Management Journal, vol. 40, no. 3, pp. 7-15.

Malone, T. W., Yates, J. and Benjamin, R. I. (1987), "Electronic markets and electronic hierarchies", Communications of the ACM, vol. 30, no. 6, pp. 484-497.

Mcfarlan, F. W. (1984), "Information technology changes the way you compete", Harvard Business Review, vol. 62, no. 3, pp. 98-103.

Porter, M. E. and Millar, V. E. (1985), "How information gives you competitive advantage", Harvard Business Review, vol. 63, no. 4, pp. 149-16

Ryssel, R., Ritter, T. and Georg, G. H., (2004), "The impact of information technology deployment on trust, commitment and value creation in business relationships", Journal of Business & Industrial Marketing, vol. 19, no. 3, pp. 197-207.

Spalding, J. O. (1998), "Transportation industry takes the right-of-way in the supply chain", IIE Solutions, vol. 30, no. 7, pp. 24-8.

Williams, L. R., Esper, T. L. and Ozment, J. (2002), "The electronic supply chain", International Journal of Physical Distribution and Logistics Management, vol. 32, no. 8, pp. 703-719. □

Feature

Industrial Utilization of Sorghum in India: An outlook

B. Dayakar Rao, K.A. Bharath Kumar & Binu Mathew

Sorghum is the fourth important cereal grain in India. In view of decline in its consumption as a staple diet over the past three decades, it is being diverted for industrial uses. However, there is scarce information available on its utilisation for non-food uses. The present study focuses on the estimation of current utilization and future potential of sorghum as an industrial raw material.

B. Dayakar Rao is a senior scientist, K.A. Bharath Kumar is a research associate and Binu Mathew is a Senior research fellow at the National Research Centre for Sorghum, Hyderabad.

Sorghum is an important dryland cereal crop valued traditionally as a major staple food in the semi-arid tropic (SAT) regions of India. However, of late it is losing its importance and is becoming increasingly marginalized in production in many areas. This is evident from the fact that sorghum grown over 16.5 m ha during the 1970s was reduced to 9.5 m ha in 2003-04 (Agricultural Statistics at Glance, 2004).

A host of factors such as the increase in production and easy availability of fine cereals such as wheat and rice, poor quality of kharif sorghum (especially hybrids), social status attached to the consumption of fine cereals etc., collectively led to the dramatic decline in sorghum consumption. However, farmers with unfavourable production environments with poor soil and water conditions in dryland areas, are left with no option but to grow sorghum not only for grain but for fodder. Thus specifically kharif sorghum is caught up in the vicious cycle of low production, low demand, low market price and ever-increasing input prices. Paradoxically kharif sorghum has found a new niche as a potential industrial raw material in poultry feed, animal feed and alcohol distilleries.

The Need for and scope of promoting alternate uses of sorghum

The overall demand for sorghum grain as food has declined by 42% during the last three decades. Further, the *per capita* consumption of sorghum in rural India declined from 1.59 kg/month in 1972 to 0.50 kg/month in 2000 and from 0.71kg/month to 0.22kg/month in urban areas during the same period (Dayakar Rao, 2004). The market value of the kharif sorghum infected with grain mould fetches an unremunerative price. Severe moulding of sorghum grain results in blackening of grain, making it unfit for human consumption, despite which sorghum cultivation is still continuing in kharif sorghum tracts mainly due to its fodder value. There-

fore, there exists a need to find an alternate use for the grain that is diverted from the food chain. In this context, the lower price of rainy season sorghum in comparison with its competitor maize, is apparently an advantage for its industrial uses. A comparison of price trends of rainy season sorghum and maize over the years indicates that the sorghum has a price advantage over maize ranging from 7% to 37%, thus it may replace or supplement maize in its industrial uses as an economically cheaper alternative. Sorghum grain is an abundant and cheap source of starch which could be put into industries such as food, feed, pharmaceuticals, textiles, and paper making. The grain starch can be processed for production of dextrose, maltose, high fructose syrups etc. The white grains and grain starch can be used for production of ethanol, citric acid, lactic acid and sorbitol. This would make the sorghum cultivation an economically viable option for marginal farmers apart from providing a supplementary / alternate and cheaper raw material to a range of industries. Therefore, the industrial applications for sorghum grain need to be explored extensively.

Background and Data Source

The present study concentrated on the estimation of existing utilization of sorghum as an industrial raw material and projecting the future potential through an exploratory industrial survey that has been carried out in seven major sorghum growing states *viz.* in Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Maharashtra and Tamil Nadu during 2002-2003. Apart from the industrial survey, the present study referred to and reviewed various secondary data sources published by Government of India and other sources.

The Indian sorghum economy

India is the third largest producer of sorghum in the world after USA and Nigeria and has the largest area under the crop. Sorghum occupied 9.49 million ha during 2003-04 in the semi-arid regions of the country (especially central and peninsular India), and produced 7.33 million tonnes of grain (Agricultural Statistics at a Glance, 2004). In India, it could be the third most important food grain after rice and wheat; however, maize took over the third position and relegated sorghum to the fourth position in terms of production. Sorghum is grown both in the kharif and rabi seasons. The kharif season sorghum is grown over 3.80 m ha (42% of area) and contributes 3.36 million tonnes (50 % of production) while the rabi sorghum covers the rest of the area and production during 2002-03. Kharif sorghum is notable for its wider adoption of high yielding hybrids which occupies 91% of kharif sorghum area. Hence the productivity of rainy season sorghum is about 40% high than that of rabi sorghum. But the kharif sorghum grain is also known for its poor quality, which is unsuitable for human consumption. The coincidence of rain during the grain maturity stage causes severe mould infestation, resulting in poor quality of kharif sorghum. Most of the research and development concerning mould recommends for the alternate uses of the mould infested grain in different industries.

Industrial utilization of sorghum

With the diminishing prospects of the household consumption, sorghum, particularly the kharif sorghum, finds its way as a raw material in different industries, as discussed below:

Sorghum grain as raw material for animal feed production has been a dynamic element in the global sorghum consumption scenario. The demand for sorghum for feed purpose has been the main driving force in raising the global production and international trade since the 1960s. The sorghum demand is heavily concentrated in the developed countries, where animal feed accounts for about 97% of total use, and in some high-income developing countries, especially in Latin America where 80% of total sorghum is utilized as animal feed. The United States, Mexico and Japan are the main consuming countries followed by Argentina, the former Soviet Union and Venezuela. These countries altogether account for over 80% of the world sorghum use as animal feed.

Dairy feed industry

In India, the population of cross bred cows is comparatively small (2.7 million in 1982). However over the period of 1982-1994, the composition of animal population changed as the number of both buffaloes and cross bred cows increased and indigenous cows decreased and registered a negative growth rate. This could be inferred as a proxy of the increasing feed demand in the dairy industry.

The ever-increasing growth in population and income has also resulted in the increased demand for milk, meat and other animal products. A study by Kleih *et al* (2000) stated that with high purchasing power and high-income elasticity of demand for milk and meat, the dairy demand is all set for a rapid growth. The current data on milk production indicates a growth of 4.14% over the last decade. In the event of its continuance, it is expected to trigger an appreciable increase in demand for animal feed concentrate. With the poor quality and low human consumption of kharif sorghum, it has a fair

demand in the animal feed industry and is expected to grow in the future.

Total feed requirement in dairy industry

In the absence of absolute figures of total feed production in India, an attempt is made to project the total feed requirement by looking into the growth rate of milk production over the last decade. The milk production in the 1990s grew by 4.14% per annum. Theoretically, the feed requirement should also grow at the same rate. The analysis assumes a daily consumption of 230 grams of grain per head of the milch animals. But apart from the milch animals, the draft animals (oxen) are also fed with concentrate feed, although the quantity used is very low. Therefore when the absolute quantity of feed requirement both for milch and draft animals is considered, it is likely that the growth in feed production will be low. Hence, a reasonable growth rate of 3.5 per cent per annum is considered for the present study.

Table 1: Sorghum utilization in major sorghum producing countries (TE 1999-2001)

(Qty in million tonnes)

User	North America		Asia		Africa	
	Qty	%	Qty	%	Qty	%
Direct food	0.54	2.86	8.91	62.74	14.85	72.22
Feed	17.00	90.23	4.18	29.43	1.60	7.78
Other users	1.3	7.12	1.11	7.81	4.11	19.99
Total utilization	18.84	100	14.20	100	20.56	100

Source: FAO Database, 2003

Figures are the annual averages

Figures do not include exports

Figures may not add up to rounding errors

Other uses includes seed, manufacturing purposes and waste

Table 2: Total milk production and feed requirement of Indian dairy industry

Year	Milk production (Million tonnes)	Total feed requirement.		Sorghum requirement		Feed production	
		@ 4.14%	@ 3.5%	@ 4.14%	@ 3.5%	by CLFMA	by Co-op
1990-91	53.90	2.85	3.01	0.29	0.30	1.32	0.03
1999-00	77.79	4.17	4.14	0.42	0.41	1.49	0.32
2005-06	99.22	5.31	5.09	0.53	0.51	1.62	0.09
2010-11*	121.53	6.51	6.04	0.65	0.60	1.75	0.16

* The values are projected based on the past trends

It is assumed that the feed requirement at four million tons (i.e., about one million ton by non-cooperative Compound Livestock Feed Manufacturer's Association (CLFMA) members, one million ton by the co-operative sector and two million tonnes by the unorganized commercial sector) in 1998-99 (Kleih *et al* 2000) and its growth rate as 3.5% per annum, the total feed requirement is expected to be 6.04 million tonnes by 2010 A.D (Table 2). At this juncture examining the inclusion rate of grain in animal feed is noteworthy. The standard dairy rations that comprise the bulk of commercial feed, include approximately 10% grain, 5-10% the by-pass feed and about 20% the high energy feed. Therefore, the total requirement of sorghum grain will be around 0.60 million tons by 2010 A.D. It should be noted here that at the farm-level, the animals (both milch and draft) are fed with grain, which go unestimated.

Table 3: Nutritional value of grains for dairy cattle and buffalo

Grain	Protein				Energy (per kg)			
	Dry Matter	Total	Digestible	TDN	Digestible	Metabolizable	Ca	P
	(%)	(%)	(%)	(%)	(Kcal)	(Kcal)	(%)	(%)
Barley	90	8.7	6.9	79	3483	-	0.06	0.33
Pearl millet	89	11.9	5.1	61	2668	2185	0.12	0.46
Sorghum	87	15.2	7.3	86	3772	3093	0.12	0.44
Maize	89	8.9	6.8	81	3571	2928	0.02	0.31
Oats	89	11.8	8.8	68	2998	2458	0.10	0.35
Wheat	89	13	10.1	78	3449	2820	0.50	0.40

Source: Diary India, 1997

Table 4: Composition of dairy feed used in major cooperatives in Gujarat

Sl. No	Ingredient	%
1	Grain (sorghum /broken rice/ragi/maize)	20
2	Rice bran	32
3	Rice polish fine	10
4	De-oiled cake	15-20
6	Total soluble proteins	2-3
7	Molasses	12
8	Bone meal	1
9	Remix-premix Minerals (Salt, Calcium, Urea and Vitamin)	5

Source: Major Co-operatives feed manufacturers, Gujarat

Another argument adding strength to feed use of sorghum comes from its comparable nutritional value with other competing ingredients. The nutritional value of different raw materials used in dairy feed (Table.3) shows that the sorghum is comparatively better than all other feed ingredients in all important parameters studied.

During our field survey in 2002, it was found that few large co-operatives in Gujarat were using sorghum grain at a 20% inclusion rate (Table 4). It is also learnt that sorghum was the major grain used for feed production. This finding was little different from the previous study conducted by Kleih *et al* (1998), which indicated a sorghum inclusion rate of about 10 % in the animal feed.

One of the important factors that determines the usage of sorghum grain in animal feed is its price. It is found that the landing price of the sorghum to these industries varied from Rs 4000/ton (Nov-Dec) to the maximum of Rs.6000/ton (Aug-Sep) in the year 2001. Broken rice is the stiff competitor for sorghum in dairy feed industry as it costs lesser than when compared to sorghum, most of the months across the year.

Indian poultry industry

Indian poultry industry is the major industry where sorghum can be put to major alternate use. During the last decade the poultry industry in India experienced an annual growth rate of 8% (layer) and 15% (boiler). Poultry population has reached up to 150 million layers and 800 million broilers, apart from 1.5 million layer parents and 12.3 million broiler parents.

Sorghum grain usage in poultry feed industry

Kharif sorghum has the ability to replace the maize in poultry feed to a great extent because of its low price compared to maize (lower by 7 to 37%). The poultry industry is currently depending largely on maize, which constitutes 30-35% of poultry ration. At times, the maize will be in short supply and it is quite expensive for the poultry farmers to use in poultry rations. In order to feed the anticipated poultry population by 2020 A.D, the maize production must be increased to 31 million tons from the present level (2003-04) of 12 million tons. Moreover due to the rapid increase in the production of poultry products, farmers are facing the problem of low product price apart from high feed cost. The non-availability of cost-effective feed ingredients is a major factor inhibiting the growth of the poultry industry. Therefore, the farmers need to go for least cost feed formulations to stand in the market.

Although sorghum has been used in the poultry feed to a limited extent, there are apprehensions regarding its usage in poultry feed, which are presented in Table 5.

Even though sorghum has the ability to replace the maize totally in poultry feed, the inclusion of the sorghum to the tune of 25 % in the feed ratio will remove the pressure from maize grain and also help the poultry and sorghum farmers earn a better profit so that they can sustain their products in the highly competitive global market.

Table 5: The perceptions and facts about sorghum grain usage in poultry feed

	Myth	Reality
1.	Sorghum has tannin	The commonly cultivated Indian white sorghum grain does not contain tannin
2.	Sorghum has very low energy compared to maize	The total calorific value (2650 and 3300 k cal per kg in sorghum and maize respectively) and nutritional composition (fibre content is 2% in both and protein is 10% in case of sorghum while it is 8.8% in maize) of maize and sorghum are similar in many cultivars
3.	Mash becomes powdery while grinding thus reducing feed intake by birds	The problem is due to the use of unsuitable machinery.
4.	Low palatability and digestibility	Disproved through field (scientific) experiments and through farmers practice

Sorghum grain requirement in poultry industry

The current requirement and the projected feed requirement for the year 2010 is presented in Table 6 and graphically in Figure 1. The prevailing growth rate of both layer (8%) and broiler (15%) industries are used for the projection. It is observed from Table 6 that the poultry industry requires more than 10 million tonnes of feed per year and that this will increase to about 26 million tonnes by the year 2010 A.D. In general, approximately 50% of the feed ration is constituted by grain source, out of which 30% is by maize and 12-15% is occupied by sorghum or by ragi, which amounts to 3 million tons of maize and about 1.3 million tons of sorghum. If the poultry industry grows at the same pace and with the same grain inclusion rate, the requirement of maize and sorghum will be about 7.8 and 3.08 million tons respectively during 2010 A D. It is believed that with the better qualities of sorghum and improved information dissemination, the inclusion rate of sorghum in poultry feed may be increased to the tune of 25%. Thus, though sorghum is not comparable fully to maize in its nutritive value (Table 7), the price advantage of sorghum over maize will give it a cutting edge in the industrial uses.

During our survey, few poultry farms at Shadnagar near Mahabubnagar district (Andhra Pradesh) revealed mixed responses regarding the use/inclusion of sorghum in poultry ration. From the farmers response it is

clear that all poultry farmers are ready to use sorghum in the feed ration up to 15% as against the present rate of 10.3%, provided that the grain is cost effective and of good quality (Table 8).

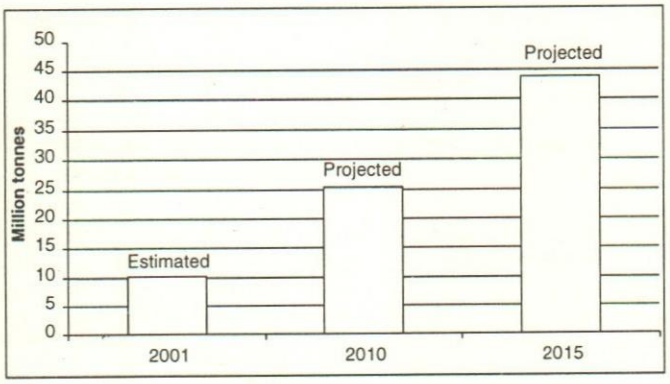


Fig. 1. Total grain requirement in poultry feed

Table 6: Estimated feed requirements by the commercial poultry sector

	Poultry population in 2001. (Million)	Feed intake Kg/bird /year	Annual growth rate	Projected feed requirement	
			(%)	2001	2010
Layers	160	40	8	6.4	13.9
Grower	800	7.5	8	0.6	1.3
Broiler	800	3.05	15	2.4	8.4
Parent stock	14.1	50 kg/bird	12	0.7	1.9
Total	1774.1			10.1	25.5

Table 7: Energy levels and constituents of market grade sorghum and maize

Constituent	Sorghum	Maize
Energy (kcal/kg)	2650	3300
Proteins (%)	10	9
Fat (%)	3	3.9
Moisture (%)	9	10
Fibre (%)	4	3
Calcium (%)	0.2	0.2
Phosphorous (%)	0.3	0.4
Lysine (%)	0.3	0.2
Methionine (%)	0.3	0.2

Source: M.P. Seshaiah, Andhra Pradesh poultry federation, Hyderabad

Maize - Industrial sorghum's main competitor

The reported maize and sorghum production during 2001 was about 14.72 and 7.73 million tonnes respectively. It is learnt that the maize production is gradually increasing while that of sorghum is decreasing and expressing a fluctuating trend. Increasing domestic maize production along with zero import duty on maize import, reserves an unbeatable position for maize in the industrial arena, especially in the poultry feed industry. But non-tariff regulations may prove to be an obstacle, which would allow Sorghum to find a niche in industrial usage to an extent. These are:-

1) Non-declaration of maize as unfit for human consumption by USA.

2) Import of maize is not cost effective and too expensive due to lack of inadequate port handling infrastructure and transport facilities.

Table 8: Composition of layer feed in poultry farms in Shadnagar (Mahabubnagar, Andhra Pradesh)

S. No	Ingredients	(%)
1	Maize	25.9
2	Sorghum / Ragi	10.3
3	Broken rice	10.3
4	Total grain	46.5
5	Groundnut cake with oil	10.3
6	Groundnut cake de-oiled / soy meal	17.2
6	Sunflower cake	8.6
7	Fish meal	6.5
8	Shell grit	8.6
9	Mineral mixture	2.2
	Vitamins	200 gms/t
	Trace minerals	1 kg/t
	Enzymes	125 gm/t

The Indian alcohol industry

In India, about 295 alcohol distilleries are operating with the installed capacity of 3198 million litres of alcohol per annum. The annual requirement of alcohol for all purposes, however, stands at about 700-2000 million litres. The alcohol industry produces alcohol for two distinct purposes *viz.* potable and industrial purposes. Potable liquor production has a steady annual growth rate of about 8%. The industrial alcohol, on the other hand is showing a declining growth trend because of high price of molasses which is a substrate for 95% of total alcohol production. The alcohol produced is now being utilized in the ratio of approximately 52% for potable and the balance for industrial use. The growing alcohol production and consumption over the years in India is shown in Table 9.

Sorghum grain in alcohol industry

The production of sorghum-based alcohol was not

encouraged in the past keeping in mind food security, since it is the third most important food grain in India. However, with the decreasing *per capita* consumption of sorghum and greater availability of rice and wheat, kharif sorghum is gaining importance as a raw material for alcohol industries. It was estimated that about 95% of the alcohol manufactured in India is from molasses and the rest from grains, roots and tubers. The potable industry has shown remarkable progress over years in the production of quality spirit from grains (Table 10). The ongoing economic liberalization has made it obligatory on the part of the Indian liquor industry to improve the quality of potable alcohol so as to compete globally. Grain-based alcohol is much cleaner because of low sulphate and aldehydes that will fit in with the stringent international quality norms. On the other hand, the molasses-based alcohol give sulphorous odour and may have a deleterious effect on health.

Table 9: Alcohol production and consumption in India

(Lakh litres)

Year	Total alcohol production	Alcohol consumption
1995	14206	10590
1996	19409	11058
1997	18957	9759
1998	19289	9933
1999	20077	10110
2000	20491	10291

Source: All India Distillers Association, New Delhi

Table 10: Proportion of grain alcohol in total potable alcohol production

Year	Potable alcohol production (lakh litre)	Alcohol Production from Grain (lakh litre)	Proportion (%)
1995	5197	282	5.43
1996	5882	297	5.05
1997	4782	313	6.55
1998	4894	329	6.72
1999	5009	347	6.93
2000	5127	365	7.12

Source: All India Distillers Association, New Delhi (2002)

Currently the market for grain-based alcohol in our country is limited. However, with rising income and high purchasing power, consumers tend to shift to quality products, which may trigger a demand for grain-based alcohol. Superior quality of alcohol from grain attracted many foreign manufacturers to India since the production cost is less compared to their home countries and also there is an abundant availability of raw material. If the government policies regarding grain-based alcohol become more favourable, there exists a possibility of annual growth rate exceeding 10% (on the basis of current annual production of potable alcohol).

Sorghum grain demand from alcohol industry

According to All India Distilleries Association (New Delhi) the grain-based alcohol contribution was 6.72% (TE 1997-1999) to the total potable alcohol production. It is estimated that about one lakh tonnes (TE 1997-1999) of grains could have been used in alcohol industries. Based on current use and projected annual growth rate of 10%, the demand for raw material is expected to be between 0.25 million tonnes to 0.33 million tonnes by 2010 A.D. The growth of the potable alcohol industries is linked to the demand for sorghum. The present study shows that sorghum contributes approximately 60% of the total grain for the potable alcohol industries. However, the ever-rising demand for broken rice, wheat and maize from other industries and for human consumption may lead to inconsistent supply of raw materials to the distilleries. Therefore, the demand for alternate raw material of sorghum in alcohol industries is expected to be between 0.18 – 0.22 million tonnes by 2010 (Fig. 2).

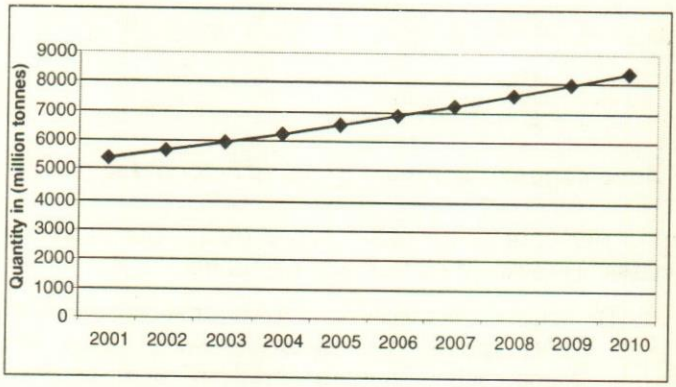


Fig. 2. Sorghum demand from alcohol industry

The Government of India's policy on blending of ethanol with petrol (biofuel) mainly to reduce the environmental pollution and reduce the petrol consumption, will also place a fair demand for ethanol. With the gasoline demand expected to increase from 7.9 m.t in 2001-02 to 11.6 m.t in 2006-07, the requirement of ethanol at 5% blending would be 682 m.lt and at the third phase of 10% blending the same would be 1364 m.lt. In the event of increased diversion of the molasses for the fuel alcohol production, the vacuum created raw material demand for potable alcohol sector will be filled by grain-based ethanol. It is also expected that cereal grains may also be diverted to fuel alcohol production in order to meet the increased demand. Overall the sorghum for ethanol production is perceived to have a fairly high demand, but not as attractive as from the

potable liquor sector. Due to fluctuations in production of sugarcane (meant for alcohol producing industries) and its price, there is an increasing tendency among farmers to diversify to other crops in order to avoid risks as well as expecting overall higher economic returns. Therefore, there will be a good demand for industrial alcohol from the grain sources in the future.

Sorghum is seen as a favourable raw material for grain-based alcohol distillers. This is because of its competitive price compared to other grains used as raw materials. The poor quality moulded sorghum grain, due to its low price can be siphoned off to the alcohol industries. The delivery cost at the distillery gate ranges between Rs 3500-4800 per ton. Thus grain moulding has become a blessing in disguise for grain based alcohol distillers.

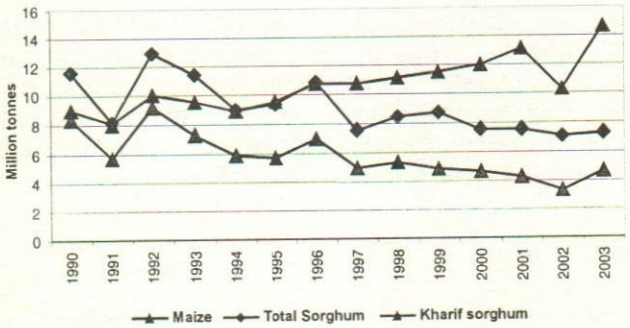


Fig. 3. Maize and sorghum production in India

Advantages of sorghum grain as alcohol feedstock

Here are some observations during our industrial visits, as revealed by technical personnel.

1) Sorghum is available at lower cost compared to other grains in sorghum growing states like Maharashtra, Andhra Pradesh and Madhya Pradesh.

2) Good quality of alcohol, free from sulphates and aldehydes can be produced.

3) Exemption of excise duty on grains when compared to molasses (Rs. 500 per ton central excise duty is waived)

4) Sorghum grain normally has a starch content of 63-67% which can give alcohol yield of 350-384 litres per ton.

5) A study by Seetharama *et al* 2002 reveals that the degradation of starch in the moulded grain is not significant and does not affect the recovery of alcohol. During fermentation process, the grain starch gets utilized and the other components such as cellulose and protein remain unutilized in the silage. The dried silage is not only rich in protein but also has vitamins produced by yeast during fermentation. Approximately 240-260 kgs of distillers dried grain and soluble (DDGS) per ton of grain is produced as a by product which can be rich animal feed.

6) Grain-based ethanol industry is posing an environmental pollution hazard, as in the case of ethanol production from molasses.

7) The cost of production of ethanol from the traditional molasses raw material and from the alternate source of sorghum grain is compared in Table 11. Cost incurred on steam/coal and electricity components and high water requirements escalate the cost of grain-based ethanol. However, the raw material (sorghum grain) cost was 10-21% lower compared to sugarcane molasses, resulting in a comparatively low price (5-19%) of sorghum grain-based ethanol. Considering the difference between costs of production of these two raw materials, sorghum grain seems to have price advantage over molasses.

8) Silica content is less in sorghum grain than in broken rice.

Table 11: Cost of production of ethanol from grain molasses

S.No	Particulars	Ethanol based on	
		Sorghum grain	Molasses
1.	Manpower	1.00	1.00
2.	Steam/coal	1.50-1.75	1.25
3.	Electricity	2.00-2.50	2.50
4.	Yeast/Enzymes	0.25-0.50	0.25
5.	Water utilization/maintenance	1.50-2.00	0.50
6.	Pollution control	-	2.00
7.	Total cost (A)	6.25-7.75	7.50
8.	Raw material (B)	8.97-10.25*	11.36*
9.	Total cost of production (A+B)	15.22-18.00	18.86

Constraints in sorghum utilization as a raw material in alcohol production

- Sorghum does not hold comparative advantage in non-sorghum growing states
- Lack of established varieties of sorghum with higher starch content, which is an input being preferred by the industries.
- Lack of market information regarding the availability and price in various markets
- Froth formation at time of decantation.
- Solid content is more in sorghum than in rice.

In a nutshell, the demand for sorghum from various industrial quarters is depicted in Table 12. The revised demand from industries for sorghum shows that the poultry feed industry (especially layer feed) is going to be the major buyer which will absorb a huge quantity of sorghum, followed by the dairy feed industry. It also shows that the alcohol industry too will have a fair demand for sorghum. But the starch industry demand for sorghum will peter out in the future.

Table 12: Summary of industrial demand ('000 t) for sorghum in India

Industry	Revised estimates[3]	
	2001-2002	2010
Poultry feed (Total)	1078^{+}-1270^{++}	2668^{+}-3085^{++}
Broilers	240	840
Layers	768-960	1668-2085
Others (grower &parent stock)	70	160
Diary feed	440-450	600
Alcohol	92	216
Starch	-	-
Brewing		-
Food industry		-
Exports	11	-
Total	1621-1823	3484-3901

Note: 1. Figures are the estimates based on current survey conducted as a part of RNPS-6 & 24 NATP projects.

Figures reflect the average sorghum utilisation during 2002 based on inclusion rates and current requirement of raw material. The starch industry figures are not readily available.

The annual growth rates considered for the projection are 8% in layer; 15% in broiler; 5% grower and parent stock; 3.5% in dairy & 10% in alcohol industry.

Sorghum inclusion rate in feed considered for the estimation are 12%.

Conclusion

It is evident that the production and trade in sorghum in recent years indicates a shift towards non-food uses from the food use. However, the following could be suggested to hasten and sustain the process of transformation of sorghum, especially kharif, as a complete, commercialized industrial raw material.

- In consultation with end-users, the ongoing research should give more emphasis to the region-specific requirements, development and distribution of varieties more appropriate for industrial use that can cater to the specific requirement of various industries.
- Providing better storage facilities as the quality of sorghum stored for 6-12 months after harvest suffers, causing problems when the grain is used for industrial purposes. So apt technology in post-harvest handling of the material needs to be developed.
- As sorghum is in the transition period, with a shift from consumption to industrial uses, the existing market structure and facilities will not be sufficient. The existing market is meant for food uses; hence the development of twin track market is the need of the hour to help the second channel (i.e.) the non-food market. Building linkage among researchers, user industry and farmer producer will be greatly helpful to avoid the role played by the so-called intermediaries, as they took the major part of the profit without much effort and left the main stakeholders in dire straights. The better link between industry and the farmers can be achieved through contract farming.
- Once implemented these suggestions will help to make sorghum a suitable and preferred raw material for industry as well a preferred crop choice for the dryland farmers.

Acknowledgements

The authors would like to thank Dr. N. Seetharama Director, National Research Centre for Sorghum, Hyderabad and Dr. Y. Eswara Prasad, Professor and Head Dept. of Agri. Economics, College of Agri. ANGRAU, Hyderabad for their review and valuable suggestions.

References

"Agriculture statistics at a glance" 2002, Ministry of Agriculture, New Delhi, India, pp62 - 68.

AIDA News letter-(various issues), Published by All India Distillers Association, Nehru place, New Delhi.

Dayakar. B, Karthikeyan. K, Seetharama. N, and Hyma Jyothi, S. (2004), "Macro-and Micro-level Changes in Consumption of Nutritious Cereals in India", National

Research Centre for Sorghum, Rajendranagar, Hyderabad, AP – 500 030, India, pp53

"Executive guide to world poultry trends", 2002, Watt publishing company, Illinois, USA.

FAO database, www.faostat.org, 2003.

Kleih U, Bala Ravi S, Dayakar Rao B and Yoganand, B. (2000). "Industrial utilization of sorghum in India.", working series no.4, Patancheru 502 324, Andhra Pradesh, India. International Crop Research Institute for Semi-Arid Tropics, 44pp

Seetharama N, Dayakar Rao, Ratnavathi, B., Shahid Parwez C.V., Binu Mathew and Bharath Kumar, K.A, (2002), "Sorghum: a potential raw material for alcohol production" *presented in seminar on* "current developments in alcohol industry" conducted by the Distillers Association of Maharashtra, 25th August 2002 at Mumbai. □

Feature

Total Factor Productivity and Productions Function Analysis for Organic and Inorganic Chemical Industry in India

A. Vijayakumar & M. Krishnaveni

Estimates of Total Factor Productivity (TFP) for organic and inorganic sectors of the chemical industry shows a rising trend in all the three direct measures of TFP. Labour productivity and Capital productivity also show a rising trend in these sectors during the study period. Estimates of the Cobb-Douglas production function reveal that return to scale is not constant for organic and inorganic sectors of the chemical industry.

A. Vijayakumar is Reader in Commerce, Erode Arts College, Erode and M. Krishnaveni is Lecturer, Karpagam Arts & Science College, Coimbatore.

In India major economic reforms have been undertaken since July 1991 with the objective of increasing the productivity and competition of the companies. The new policies have liberalized many government controls on production capacity, imported capital goods, which have made intermediate inputs cheaper and more accessible to both domestic and international competition. These reforms have altered the economic environment in which companies operate. Therefore, an attempt has been made in this part to analyze the impact of these reforms on productivity of the Indian chemical industry.

The study is done for the two groups of Indian Chemical industries, viz., (1) organic and (2) inorganic. The period chosen for this study is 1991-2002.

Concept of productivity

The study of productivity of the factors of production is important in view of the limited availability of the factors of production, particularly capital. Depending upon the nature of the product and the process of production, different industries employ different combinations of the factor inputs. In the labour intensive industries using unskilled and or semi-skilled workers with a relatively low wage rate, the emphasis is on increasing the productivity of capital. On the other hand, in the capital-intensive industries, the prime concern is to increase labour productivity. As such, there are considerable variations in the factor intensities across different industries as well as different states. Therefore, when the objective is to examine variations in the levels of productivities, the concept of total productivity rather than partial productivity becomes more relevant.

Concept and Methods of measurement of TFP

The concept of Total Factor Productivity (TFP)

defined as the ratio of output to a weighted combination of input has been used. Three methods of measuring TFP, namely, Kendrick Index, Solow Index and Divisia Index, which differ from one another with regard to the weighting scheme, have been used.

$$\text{Total Factor Productivity(TFP)} = \frac{\text{Output index}}{\text{Factor Input Index}}$$

The above three methods of measuring TFP are based on the assumption of constant returns to scale, perfect competition and payment to factors according to their marginal product.

Kendrick Index

The Kendrick Index is the ratio of the actual output to change in output, which would have resulted from the use of increased inputs in the absence of technological changes. It is defined as

$$TFP(K) = \frac{V_t}{W_0 L_t + r_0 K_t}$$

Where V stands for indices of real value added, L for indices of Labour, K for indices of Capital, W_0 and r_0 being the share of labour and capital in value added in the base year.

Solow Index

Solow Index of TFP is based on the rate of productivity change and is obtained as follows:

$$\frac{\Delta A_t}{A_t} = \frac{\Delta V_t}{V_t}\left\{W_t \frac{\Delta L_t}{L_t} + r_t \frac{\Delta K_t}{K_t}\right\}$$

Where $\frac{\Delta V_t}{V_t}$, $\frac{\Delta L_t}{L_t}$ and $\frac{\Delta K_t}{K_t}$ are the rates of change in the real value added, labour and capital and W_t or r_t is the share of labour and capital in value added in year t. The total factor productivity is

$$A_{t+1} = A_t \left[1 + \frac{\Delta A_t}{a_t}\right] \text{ for base } A_{t=1}$$

Divisia Index

Divisia index of TFP is also based on the rate of productivity change and is obtained as follows

$$\frac{\Delta P_t}{P_t} = \frac{\Delta V_t}{V_t}\left[\overline{W}_t \frac{\Delta L_t}{L_t} + \overline{r}_t \frac{\Delta K_t}{K_t}\right]$$

Where $\frac{\Delta V_t}{V_t}$, $\frac{\Delta L_t}{L_t}$ and $\frac{\Delta K_t}{K_t}$ are approximated by corresponding logs of ratios of variables over successive year respectively and

$$\overline{W}_t = \tfrac{1}{2}(W_{t+1} + W_t) \text{ and}$$

$$\overline{r}_t = \tfrac{1}{2}(r_{t+1} + r_t)$$

Where w_t and r_t are the shares of capital and labour in value added. The Divisia Index is then derived as

$$P_{t+1} = P_t \left[1 + \frac{\Delta P_t}{P_t}\right], \text{ Where } P_{t=1}$$

The above methods of measuring TFP are based on the assumption of constant returns to scale, perfect competition and payment to factors according to their marginal product.

Production function Method of Estimating Growth Rate of TFP

In the production function approach to measure TFP, we relax the constant return to scale.

Cobb-Douglas (CD) Production Function

The CD production function including the technological progress variable can be stated as follows

$$V = Ae^{\lambda t} L^{\alpha} K^{\beta}$$

Where V is value added, L is Labour, K is Capital and t is time. Further elasticity of Labour and Capital are given by α and β respectively and exponential growth rate of TFP is given by λ. This function implies unitary elasticity of substitution. The log form of CD production function is given by

$$\text{Log } V = \text{Log } A + \alpha \text{ Log } L + \beta \text{ Log } K + t$$

It can also be reformulated as

$$\text{Log } (V/L) = a + b_1 \log (K/L) + b_2 \log L + t$$

$$\text{Where } b_1 = \beta \; b_2 = \alpha + \beta - 1$$

If return to scale is unity, then the co-efficient of log L should be significant.

Constant Elasticity of Substitution (CES) production Function

CES production function including exponential

technological progress variable can be stated as follows:

$$V = Ae^{\lambda t} [\delta L^{-P} + (1-\delta) K^{-P}]^{-V/P}$$

Where V is value added, L is Labour, K is capital, t is time and δ is distribution parameter. V gives returns to scale. P is related to elasticity of substitution by the following formula:

$$\sigma = 1/(1 + p)$$

and λ is exponential growth rate of TFP. For estimating CES production function we consider equation based on equality of marginal productivity of labour to wages (w). Under the assumption of perfect competition and profit maximization:

$$\text{Log } V/L = a + b_1 \log w + b_2 t + b_3 \log L$$

Where $b_1 = V / (V+P)$

$b_2 = \lambda p / (V+P)$

$b_3 = P (V-1) / (V+P)$

$\sigma = b_1 / (1+ b_3)$

If a return to scale is constant, then co-efficient b_3 is significant. If co-efficient b_3 is insignificant implying returns to scale to be unity, then co-efficient b_1 gives elasticity of substitution.

Functions for Annual Variations in Factor Productivity

It is postulated that factor productivity depends on scale of production and institutional framework such as labour-management relations. Growth in scale of production permits adoption of technologies, which improve productivity. Expansion of scale also provides division of labour, which in turn improves the productivity. Labour management relations affect motivation of workers, which in turn affects their will to work.

Based on the above hypothesis, function for TFP is specified as below:

$$P = f(v, t)$$

where P = Productivity index

V = real value added as proxy for scale of production

T = time variable as proxy for management and labour relations.

For P, all measures of total factor productivity (TFPK, TFPS, TFPD) and partial productivity of labour are taken separately. The functions are estimated in log form.

Review of Empirical Studies on Productivity Analysis

Anita Kumari (1993) studied the "Productivity in the public sector - Analysis at Industrial Group Level". In this study an attempt has been made to analyse productivity trends at the group level of public sector enterprises for 11 groups of manufacturing industries - steel, minerals and metals, coal, chemicals, power, petroleum, heavy engineering goods, transportation equipment, consumer goods and textiles. The period chosen for the study is 1971-72 to 1987-88. The purpose of this study is to measure total factor productivity as well as partial factor productivity for various public sector groups over time. Further, an attempt has also been made to explain the annual variations in factor productivity with the help of multiple regression frameworks. Finally, inter-group variations in productivity have also been discussed. Analysis of productivity trends at the group level reveals marked inter-industrial differences in productivity growth. Estimates of total factor productivity for steel group and consumer goods group shows a falling trend in all the three measures of total factor productivity. Labour and capital productivity for these groups also show a falling trend. But in the remaining groups estimates of total factor productivity show a rising trend in all the three measures.

Tarlok Singh and D. Ajit (1993) studied the production function in the manufacturing industries in India from 1974-1990. This study examines the sources of growth in various industries in the manufacturing sector in India using conventional production function (Cobb Douglas, C.E.S and Tanslog) as well as a new production function recently introduced by Burman production function. The study period was 1973-74 to 1989-90 i.e., 17 years. The study finds that Cobb Douglas and Burman production function perform better than other production functions and the results of the study confirms the validity of decreasing returns to scales for most of the industries in the manufacturing sector.

Balakrishnan and Pushpakandan (1994) raised the question on the validity of TFPG estimates obtained on the basis of single deflation method of measurement of real value added. They argued that the single deflation method of real value added yields bias in the estimates of TFPG especially in the presence of non-consistency of index of relative price of raw materials. In order to construct an index of materials input, a series of weighted average of wholesale prices of 19 major inputs have been constructed, and the weights have been cal-

culated from the matrix of input-output transactions published by the Central Statistical Organization (CSO). They rejected the presence of the phenomenon of "turn-around" in the TFPG in the early eighties as forwarded by Agluwalia (1991). Their estimates of TFPG for the aggregate Indian manufacturing sector for the period 1970-71 to 1988-89, which were based on the double deflation method of measurement of real value added indicated that, contrary to belief, productivity growth in the 1980s may actually have been slower than in the earlier period.

Singh and Ajit (1995) estimated different parameters of production function for Indian industries by using ASI data for the period 1974-90. They used both conventional production function specifications, namely, Cobb-Douglas, CES and Translog, as well as new production function introduced by Bairam (1989). The results showed that the agro-based industries have lost their shares not only in manufacturing output, fixed capital and employment during 1974-90. Similar trends were evident in engineering industries. However, the shares of chemical industries in manufacturing output, fixed capital and employment have shown improvements. There has been an increase in use of capital relative to that of labour in most of the manufacturing industries. Capital productivity recorded marginal improvements in the seventies, followed by a gradual decline in the eighties. The labour productivity has shown steady improvements during 1974-90, with signs of significant improvements in the eighties. Among the production functions, Cobb-Douglas and Bairam production functions performed better than CES and Translog production function. The poor performance of the latter two production functions (CES and Translog) can be attributed to the obvious problem of multi collinearity accentuated by the appearance of quadratic and cross- product terms.

Srivastava (1996) has estimated production function for aggregate Indian manufacturing and various two-digit industries using panel data for public limited companies for the period 1980 to 1989. The data have been extracted from the balance sheets of companies available with the Reserve Bank of India (RBI). A three-input (Cobb-Douglas and Translog) model has been used taking capital, labour and materials as the three inputs. The production function has been so specified as to allow a Hicks-neutral productivity factor varying across firm and over time. He has paid particular attention to the estimation problems associated with the panel data and emphasized the need for choosing an appropriate estimator. The author applied a number of alternative estimators including the "dummy variable" or "within" estimator, the "between" estimators, the first and higher order difference estimators and the generalized method of moments, instruments variable estimators. The study reported a decline in productivity in the liberalization policy regime since the 1980s.

Ramaswamy, K.V (1996) pooled the data for 18 industry groups for the period 1975 to 1990 and estimated a multiple regression model with a time dummy to capture the effects of two periods, 1974-75 to 1979-80 and 1980-81 to 1989-90. He regressed the labour productivity growth on output growth rates, net entry and capital intensity. He found that output growth has a positive effect on productivity growth. His estimates supported the hypothesis that entry in the period of industrial deregulation had a positive impact on productivity growth.

Beghel and Pendse (1997) made an attempt to analyse productivity trends and statistical estimation of production function and technical change in the aggregate manufacturing sector in India. The ASI data for the period 1973-74 have utilized for computing Solow and Kendrick indices of TFP growth along with partial factor productivity indices of labour, capital and raw material and econometric estimation of Cobb-Douglas, CES and VES production functions. The analysis revealed that the Indian manufacturing sector has not experienced technological change which was evident from the growth rates of TFP growth indices as well as parameters of time variable in the production functions. The excessive doses of capital have not resulted in technological progress in the Indian manufacturing sector as the capital intensity is found to be increasing all the time. The study suggested that there is a need to promote R & D efforts in the manufacturing sector of India so that it may survive in the newly emerging era of globalization and liberalization.

Keya Sengupta (1998) has made a study of "An empirical exploration of the performance of fertilizers industry in India: An econometric analysis". The controversy relating to the provision of fertilizers subsidy and the recent debate over its withdrawal has necessitated the present study to examine the performance of the fertilizers industry in India. Analysis of cost functions and Cobb-Douglas production function have been made to study the performance of the industry, the results of which reveal that the industry is subject to the law of increasing costs. The findings are further supported by the examination of the production function, which reveals that the average productivity of labour exceeds its marginal productivity. Analysis of shifting cost functions further highlight that the firms belonging to this industry expand capacities, even before fully exploiting the existing capacity conforming to the oligopolistic behavioural tendency of the firms belonging to the fertilizers industry.

Ghosh and Neogi (1998) tried to see the impact of liberalization on the performance of four selected industry groups, namely, (i) chemicals,(ii) textiles (iii) non-metallic mineral products, and (iv) electrical machinery, by using firm level data for the period 1989-94. The performance indicators chosen to verify the impact of economic reform on the firms were growth of value added capital intensity, labour productivity and total factor productivity. The estimates of technical efficiencies of selected industrial groups have been obtained by using frontier production model with the help of Correlated Ordinary Least Square (COLS) method. The results indicated that productivity growth and efficiency levels have not improved as per expectation during the post–reform period and the distribution of efficiency is skewed. The TFP growth has fallen very sharply during the period of reforms with the exception of the chemical industry. The relationship between labour and productivity and capital intensity indicated a general downfall of efficiency of firms during the study period. The level of technical efficiency for all the industries was found to be very low and no significant improvement has been observed in this level during the post-reform period.

Pradhan and Barik (1999) captured the total factor productivity growth during the period 1963-93 for aggregate manufacturing sector and eight selected industries by estimating the Translog cost function. The scale factor for aggregate Indian manufacturing sector was found to be less than unity and a declaration in scale factor during the 1980s has been noticed. Except pulp and paper, a declaration in scale factor has been found in all selected industries in 1980s. For the aggregate manufacturing sector and most of the individual industries, a declining trend in technical change has been noticed in recent years. On the whole, a declining trend of TFPG in Indian manufacturing sector – both at aggregate and disaggregate levels, has been noticed. They observed that a decline in both scale economies and technical change seems to have produced the present character of TFPG, although decline in the latter does not appear to be as great as the former.

R.N. Agarwal (2001) studied the Technical Efficiency and Productivity Growth in the Central Public Sector Enterprises in India during 1990s. The study is based on the data for 58 large Central Public Sector Enterprises (CPSE) manufacturing / producing goods as well as data on industry groups provided by the Department of Public Enterprises, Ministry of Industries, Government of India for the period 1990-1 to 1998-99. The objective of the study is to analyse the technical change, technical efficiency and total productivity growth of CPSE, industry group-wise and firm-wise. Partial productivities and the Solow index of total factor productivity growth have been used for estimating productivity growth at the industry group level while the panel data estimation method using the Random Effects Model and a modified form of the composite Error Term Frontier production Function Model as developed by Cornwell, has been used for the estimating the technological change during and growth of technical efficiency at the firm level. The results show that the public sector enterprises have not experienced a significant technological change during the 1990s. Further, the results point to a decreasing return to scale in production. Results also suggest that a majority of the firms have low levels of technical efficiency and that the efficiency has not improved significantly over time. However, the growth of technical efficiency is observed in some firms in the engineering sector and many firms in the petroleum producing / selling sector.

Measurement of Variables

Estimate of Value Added

The data for arriving at the partial factor productivity and total factor productivity are obtained from the summary results of Prowess database. Data relating to value added, number of employees and value of gross fixed capital are taken from this database. The Prowess database provides value added at current prices. Value added at current prices has been deflated by indices of wholesale prices given in Index number of Wholesale Prices (Base 1981-82 = 100) in India. For the chemical industry, the index numbers of drug, base industry chemicals, fertilizers, paints and pesticides are applied.

Estimate of Gross Fixed Capital

The value of gross fixed capital stock at constant (1981-82) prices has been taken as the measure of capital input. The value of gross fixed capital stock is obtained by adding gross block, unallocated expenditure during construction, capital work in progress and others. To estimate the time series of the real fixed capital stock, the perpetual inventory method is employed. Once the estimate of real gross fixed capital for the bench year is obtained, the real gross investment of the next year is added to this to obtain real gross fixed capital for the entire period. The same procedure has been followed throughout. To get the deflator for gross fixed capital, the Wholesale Price Index of Machinery and Machine tools at 1981-82 prices have been applied.

Estimate of Factor Share

Labour share has been calculated as the percentage of share of salaries and wages, etc., in gross value added at current prices. The capital share then obtained

as a residual subtracting the labour share from the corresponding value added at current prices.

Estimate of Wage Rate

The estimate of wage rate was obtained by dividing the salaries and wages and other benefits including bonus by the total number of employees. Further wage rates were deflated by the corresponding wholesale price indices at 1981-82 prices, which are the same as those used for deflating gross value added at current prices. Time (t) has been taken as proxy for technical change and residual effects and inserted in the regression equation as 1,2,3...n i.e., for 1991-92, 1992-93 and so on up to 2001-02.

Empirical Findings

Estimates of factor productivities, production functions and regression functions for annual variations in factor productivities are presented in Table 1 to Table 6. The total factor productivity and partial factor productivity are also shown in figures 1 and 2.

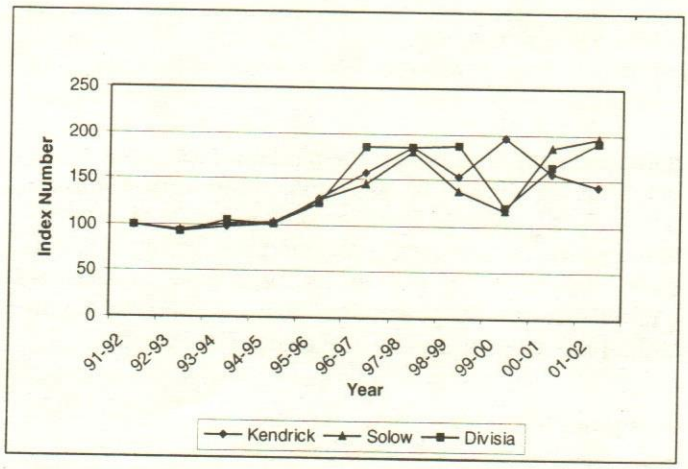


Fig. 1. Total Factor Productivity Index of Organic Industry (1991-92 to 2001-02)

Organic Industry

Estimates of Factor Productivities

To examine movements in TFP over the time period of 1991-92 to 2001-02 in the Indian Organic Industry, the three measures of TFP i.e., Kendrick, Solow and Divisia Indices are calculated and presented in Table 1.

The Kendrick index is marked by frequent fluctuations. From a base of 100 in 1991-92, it first raises and reaches a peak of 196 in 1999-00. But in the year 1998-99, it goes down to 153. Afterwards it starts falling and shows an index of 143 in 2001-02. Solow index and Divisia index also reveal fluctuations. Solow index first starts increasing and reaches 180 in 1997-98. Then it starts falling down and shows an index of 117 only in 1999-00. Then again the index goes on increasing till 2001-02 where the index is 196. Divisia index with a peak of 187 in 1998-99, falls down to 120 in 1999-00. The index starts rising again and reaches a level of 190 in 2001-02. On the whole all the indices show an increasing trend till 1997-98, recording a peak of 196 in Kendrick index in the year 1999-00, 196 in Solow index and 190 in Divisia index in the year 2001-02. Annual growth rates of TFP over the entire period are 0.94 per cent, 0.96 per cent and 0.96 per cent respectively due to the Kendrick, Solow and Divisia method.

Table 1: Indices of Total Factor Productivities of the Indian Organic Industry (1991-92 to 2001-02)

Year	Total Factor Productivities			Partial Productivity	
	Kendrick Method	Solow Method	Divisia Method	Labour	Capital
1991-92	100	100	100	100	100
1992-93	93	94	92	109	85
1993-94	98	102	105	185	106
1994-95	101	103	101	103	190
1995-96	129	128	124	117	131
1996-97	158	145	185	177	168
1997-98	185	180	186	172	179
1998-99	153	138	187	136	120
1999-00	196	117	120	178	162
2000-01	158	185	165	190	188
2001-02	143	196	190	105	114
CAGR	0.94	0.96	0.96	1.19	1.10

Source: Computed

Labour productivity and capital productivity indices for the organic industry are also shown in Table 1. Labour productivity is marked by fluctuations during the study period. From an index of 100 in 1991-92, it first rises and reaches 185 in 1993-94. Then it starts falling and comes down to 103 in 1994-95. Labour productivity again picks up and reaches a maximum of 190 in 2000-01. Capital productivity shows fluctuating trend over the entire period. It first starts rising and reaches a peak of 190 in 1994-95. Then it starts falling and comes down to 114 in 2001-02 with ups and downs in between. Over the entire period labour productivity increases at an annual rate of 1.19 per cent whereas capital productivity increases at an annual rate of 1.10 per cent.

Table 2: Estimates of Production Functions: Organic Industry (1991-92 to 2001-02)

Eq. No	Dependent Variable	Co-efficient of					R^2	Adj R^2	F	DW
		Constant	Log (K/L)	Log (W)	Log (L)	T				
1	Log (V/L)	16.091 (-1.823)	0.448* (4.070)	,0.658* (4.556)	0.1592 (1.660)	0.1592 (1.660)	0.73	0.6 9	11.14	1.713
2	Log (V/L)	14.916 (-1.909)		0.875* (4.098)	8.042* (3.262)	0.299* (4.368)	0.58	0.33	1.16	2.163

Notes: 1. Equation (1) refers to CD function. 2. Equation (2) refers to CES function.
3. Figures in parenthesis denote 't' values. 4. * indicates significance at 5 per cent level.
5. V-Value added; L-Labour; K- Capital; W- Wage rate; t- time; DW- Durbin - Waston.

Source: Computed

Table 3: Regression functions for Total Factor Productivity and Labour Productivity: Organic Industry (1991-92 to 2001-02)

Eq. No	Dependent Variable	Co-efficient of			R^2	Adj R^2	F	DW
		Constant	Log (V)	t				
1	Log(TFPK)	2.176 (3.755)	1.621* (14.158)	-4.456* (3.720)	0.91	0.83	18.91	2.194
2	Log (TFPS)	3.619 (2.820)	2.282* (12.852)	-2.940 (1.109)	0.48	0.23	1.18	1.221
3	Log (TFPD)	3.831 (2.744)	0.4225* (16.626)	-3.835 (1.329)	0.49	0.24	1.27	1.170
4	Log (LP)	5.112 (5.088)	7.126* (6.488)	-6.181* (2.977)	0.73	0.53	4.43	2.661

Notes: 1. Figures in parenthesis denote 't' values. 2. * indicates significance at 5 per cent level.
3. TFPK- Kendrick Method; TFPS- Solow Method; TFPD- Divisia Method; LP- Labour Productivity; DW- Durbin Waston.

Source: Computed

Productivity Estimates based on Production Function

Production function estimates for this industry are given in Table 2. In the CD function, the co-efficient of log L is significant. This indicates that a return to scale is not constant. The co-efficient of log (K/L) is also significant with a positive sign. Co-efficient of time is insignificant. Annual growth rate in TFP given by this co-efficient is 15.9 per cent. In CES production function, co-efficient of log L is significant. Returns to scale is, thus, not constant. The co-efficient of W implies that elasticity of substitution is less than unity. The co-efficient of time is significant. The growth rate of TFP is 29.9 per cent.

Functions for Annual Variations in Factor Productivities

Table 3 gives regression functions for annual variations in factor productivities for organic industry. In all the functions for TFP, co-efficient of real value added is positive and highly significant and that of time is negative and significant only in the Kendrick method. Growth in scale of production has been generating in total factor productivity but labour management relations have been deteriorating the total factor productivity in the organic industry. In function for partial factor productivity of labour, co-efficient of real value added turns out to be positively significant. Thus, growth in scale of production has been generating labour productivity. Co-efficient of time turns out to be negatively significant. Labour management relations have been adversely affecting labour productivity in the organic industry.

Inorganic Industry

Estimates of Factor Productivities

Factor productivity indices for the inorganic industry over a period of 1991-92 to 2001-02 are presented in Table 4. A Kendrick index is marked by frequent fluctuations. From a base of 100 in 1991-92, it first rises to 113 in 1992-93. Then it starts falling down to 104 in 1994-95. After that again it moves up and down and falls down to a low level of 102 in 1999-00. Then it starts gaining and reaches a level of 193 in 2000-01. Solow index, on the other hand, after showing an increase in 1992-93, falls down to 102 in 1994-95. Then again it starts increasing and records a peak of 181 in 1999-00 with fluctuations in between. Divisia index follows the pattern of Solow index. After rising to 182 in

1992-93, it falls down to 105 in 1994-95. It starts increasing again and records a peak of 197 in 2000-01 with ups and downs in between. Kendrick index increases at an annual rate of 1.05 per cent over the entire period. Solow index and Divisia index increases at an annual rate of 1.02 per cent and 1.33 per cent respectively over the entire period.

Table 4: Indices of Total Factor Productivities of the Indian Inorganic Industry (1991-92 to 2001-02)

Year	Total Factor Productivities			Partial Productivity	
	Kendrick Method	Solow Method	Divisia Method	Labour	Capital
1991-92	100	100	100	100	100
1992-93	113	105	182	82	112
1993-94	106	106	102	95	169
1994-95	104	102	105	91	118
1995-96	119	136	132	135	123
1996-97	179	155	193	196	181
1997-98	143	142	142	160	107
1998-99	177	116	181	172	101
1999-00	102	181	127	122	121
2000-01	193	141	197	177	165
2001-02	107	179	179	144	164
CAGR	1.05	1.02	1.33	0.91	1.15

Source: Computed

Labour productivity shows the fluctuating trend with an annual growth rate of 0.91 per cent. Over the entire period, it moves up and down with a lowest index of 82 in 1992-93 and highest index of 196 in 1996-97. Capital productivity after rising to 169 in 1993-94 declines to 101 by 1998-99. But in the year 1996-97, it reaches a peak of 181. Annual growth rate of partial productivity of capital is 1.15 per cent over the entire period.

Productivity Estimates based on Production Function

Production function estimates for the inorganic industry is given in Table 5. In case of CD production function, co-efficient of log L is significant. This indicates that a return to scale is not constant. But the sign of this co-efficient is negative. The co-efficient of log K/L is also significant. Co-efficient of time is significant. Annual growth rate in TFP given by this co-efficient is 9.6 per cent. In the equation of CES production function, co-efficient of log L is significant. Thus returns to scale are not constant. The sign of this co-efficient is negative. Co-efficient of W implies that elasticity of substitution is less than unity. The co-efficient of time is insignificant. Growth rate of TFP is 11.2 per cent.

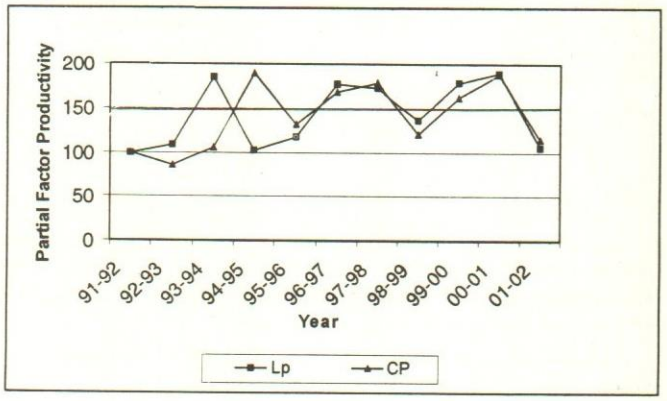


Fig. 2. Partial Factor Productivity of Labour and Capital of Organic Industry (1991-92 to 2001-02)

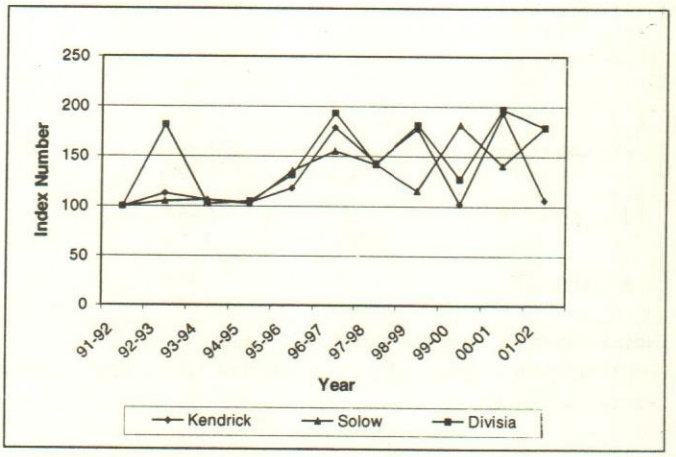


Fig. 3. Total Factor Productivity Index of Inorganic Industry(1991-92 to 2001-02)

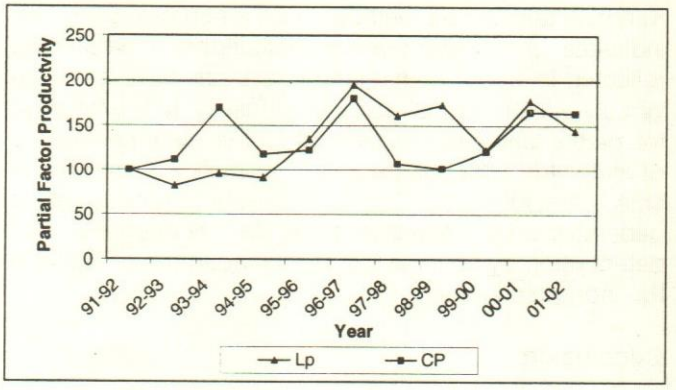


Fig. 4. Partial Factor Productivity of Labour and Capital of Inorganic Industry(1991-92 to 2001-02)

Functions for Annual Variations in Factor Productivities

Regression functions for annual variations in factor productivities for inorganic industry is given in Table 6. In functions for TFP, co-efficient of real value added

Table 5: Estimates of Production Functions: Inorganic Industry (1991-92 to 2001-02)

Eq. No	Dependent Variable	Co-efficient of					R^2	Adj R2	F	DW
		Constant	Log (K/L)	Log (W)	Log	t				
1	Log (V/L)	12.470 (-1.735)	0.723* (3.739)		-0.422** (-1.948)	0..096* (3.491)	0.88	0.74	13.59	1.483
2	Log (V/L)	-16.228 (-4.058)		0.304** (2.044)	-0.498* (-2.891)	0.112 (0.823)	0.66	0.44	6.80	1.890

Notes: Equation (1) refers to CD function. Equation (2) refers to CES function.
Figures in parenthesis denote 't' values. * indicates significance at 5 per cent level.
** indicates significance at 10 percent level
V-Value added; L-Labour; K- Capital; W- Wage rate; t- time; DW- Durbin - Waston.
Source: Computed

Table 6: Regression functions for Total Factor Productivity and Labour Productivity: Inorganic Industry (1991-92 to 2001-02)

Eq. No	Dependent Variable	Co-efficient of			R^2	Adj R^2	F	DW
		Constant	Log (V)	t				
1	Log(TFPK)	7.750 (3.598)	1.980 (1.443)	-7.798** (2.047)	0.59	0.35	12.18	1.985
2	Log (TFPS)	3.095 (2.518)	1.464 (1.197)	-3.060 (1.410)	0.84	0.70	19.52	1.441
3	Log (TFPD)	7.533 (3.352)	1.857 (1.209)	-7.411** (1.865)	0.57	0.32	3.90	2.516
4	Log (LP)	5.871 (2.688)	1.443 (0.643)	-8.489** (2.198)	0.73	0.53	8.49	1.634

Notes: Figures in parenthesis denote 't' values. ** indicates significance at 10 per cent level.
TFPK- Kendrick Method; TFPS- Solow Method; TFPD- Divisia Method; LP- Labour Productivity ; DW- Durbin - Waston.
Source: Computed

turns out to be insignificant with a positive sign. Thus growth in scale of production has been tending to generate total factor productivity. Co-efficient of time, on the other hand, turns out to be significant in the Kendrick and Divisia methods, with a negative sign. This indicates that deteriorating institutional environment reflected in labour-management relations have been adversely affecting total factor productivity. In the function for partial factor productivity of labour also, co-efficient of real value added is positively insignificant and that of time is negatively significant. Thus, labour productivity is generated by significant scale economies but deteriorates by adverse labour management relations in the inorganic industry.

Conclusion

Analysis of productivity trends at the group level marked inter-industrial differences in productivity growth. Estimates of TFP for organic and inorganic sectors of the chemical industry shows a rising trend in all the three direct measures of TFP. Labour Productivity and Capital Productivity also show a rising trend in these sectors during the study period. Estimates of the Cobb-Douglas production function reveals that returns to scale is not constant for organic and inorganic sectors of chemical industry during the study period. Further, elasticity of substitution is less than unity for organic and inorganic sectors of Indian chemical industry during the study period.

Annual variations in factor productivities have been explained with the help of regression functions. A significant positive relationship is observed with value added for organic and inorganic sectors of Indian chemical industry. This shows that expansion in scale of production has been generating growth in total factor productivity. On the other hand with time a significant negative relationship is observed for organic and inorganic sectors. Again in case of the organic sector, though the relationship with time is negative this is significant only in the Kendrick index. For the inorganic industry also, the relationship with time is negative but significant only in respect of Kendrick and Divisia index. This indicates that the deteriorating institutional environment, as reflected in labour management relations have been adversely affecting the total factor productivity. It is concluded that growth in factor productivities would have been much higher if labour-management relations had been

better in organic and inorganic sectors of the Indian chemical industry.

References

Anita Kumari (Nov 1993). "Productivity in the public sector - Analysis at Industrial Group Level", Economic Political Weekly, pp. 145- 162.

Tarlok Singh and D. Ajit (1993). "Production function in the manufacturing industries in India: 1974-1990", pp- 125-155.

Balakrishnan, P. and K.Pushpakandan (1994). "Total Factor productivity Growth in manufacturing Industry: A fresh Look". Economic and Political Weekly. pp 2028-35.

Singh, T. and D. Ajit (1995). "Production function in the manufacturing industries in India: 1974-90". Reserve Bank of India Occasional papers. Vol.16, No.2, June, pp.241-66.

Srivastava (1996). "Productivity growth and technical efficiency in manufacturing firms in India". Deep and Deep Publications, New Delhi.

Ramaswamy, K.V (1996). "Productivity of the Indian manufacturing industries". Print well Publishers, Jaipur.

Beghel, L.M.S. and Pendse (1997). "An econometric Analysis of productivity Growth and Technical Change in Total manufacturing sector of India". The Indian Economic Journal. Vol.44, No.2, pp.39-58.

Keya Sengupta (Sep 1998). "An empirical exploration of the performance of fertilizers industry in India: An econometric analysis. Artha Vijnana". Vol.XL, No.3, pp.252-262.

Ghosh, B. and C.Neogi, (1998). "Impact of Liberalization on performance of Indian industries firm Level Study". Economic and political Weekly. pp. M16-M24.

Paradhan G. and K.Barik (1998). "Total Factor Productivity Growth in Developing Economies: A Study of Selected Industries in India". Economic and Political Weekly. pp. M92-M97.

R.N.Agarwal (March 2001). "Technical Efficiency and Productivity Growth in the Central Public Sector Enterprises in India during 1990s". pp.1-24. □

You don't need all the glory. If you let others take the credit, it makes them feel like they're part of something special.

– Ralph Roberts

Feature

The Scope of JIT Implementation

Sanjay Sharma & D.K. Singh

The objective of this study is to examine the scope of JIT systems (just-in-time) and to find out the feasibility of further enhancing its usage. The study concludes that if companies are made well aware of JIT techniques and possible benefits, they will no longer lag behind, but rather take part actively in JIT implementation.

Sanjay Sharma and D.K. Singh are faculty at the Netaji Subhash Institute of Technology, New Delhi.

JIT stands for just-in-time. It was initially used by the Toyota Motor Company of Japan, after which it took them 20 years to fully implement the JIT system. It is assumed to be a very effective means to reduce the wastage of inventory and to keep it at its minimum level. It is an important management philosophy to control the flow of materials within a company. It helps to improve the manufacturing efficiency by eliminating non-value added activities. JIT focuses on inventory to be supplied to concerned sections when it is needed and not before. It has been shown that JIT is a strategic philosophy which has the potential to increase the organizational efficiency and effectiveness of the organization (Vokurka and Davis, 1996).

Prerequisites for Implementing JIT

Product Quality and Customer Satisfaction

Quality is not simply connected with conformance to specifications laid down for a product, rather it goes beyond that. A quality product is that which can meet the requirements of a customer. Whatever a customer wishes, he finds in the product. A good quality product has a better chance of its adoption in the market than a low quality product. Industries have become increasingly aware of the importance of quality. Today, companies are realizing that in order to exist in the market, they must listen to the customers' requirement or lose market share. Quality is being used as a business strategy to increase market share (Besterfield, H et al. 2000). In fact, the customer is well aware of the quality products and has become more and more demanding. Customers are more quality conscious now than in the past. Customer satisfaction ultimately becomes the major goal of the organization, and acts as a measure of quality for the organization (Besterfied, 2000). The concept of total quality management (TQM) has further broadened the concept of quality to mean not just customer satisfaction but rather delighting the customer. To meet the ongoing changes in the perception about the quality demanded by the customer, the process of attaining quality is not static and requires continuous im-

provement, which is the basic theme of TQM. The Kaizen principle helps in the attainment of TQM. ISO 9000 Certification is another parameter which helps to improve the product quality.

Stable Environment

Managing within a just-in-time environment is a challenging task. The task of implementing JIT becomes easier with a stable and chaos-free production environment. It smoothens the flow of materials within the organization. It helps to achieve on-time delivery and meet the deadlines. Lead times are drastically reduced, which ultimately helps to reduce the time by which a product reaches the customer.

On the other hand, any chaos, disorder or stoppage in the production line will adversely affect JIT implementation. The shipment of raw materials and components must be reliable because of the low inventory levels in the JIT Systems. A plant can be shut down because of a lack of materials (Krajewski et al, 2000). The unpredictable demand pattern is another factor which can obstruct the JIT implementation.

Collective Atmosphere

JIT works more effectively and efficiently in a collective atmosphere. It stresses team work rather than individual effort, seeks cooperation from every section in the organization and involves total employee participation. Everybody can contribute in JIT implementation and even a very small gain matters, which is as per the concept of Kaizen. Deming was more emphatic on the role of management in the attainment of quality in the JIT system and the role of workers was completely ignored. The significance of involvement of top level of management and proper employee training was stressed (Vora and Saraph, 1990).

Strong Supplier-Manufacturer Relationship

A close working relationship between supplier and manufacturer is absolutely required for successfully implementing JIT. The close relationship helps them to understand each other and avoid uncertainty regarding supply of materials by the supplier. This relationship makes the suppliers feel part of the manufacturing system and is based on the mutual interest of both parties. The significance of strong working relationships with vendors was stressed by Hobbs (1997), Lee (1996), Wafa et al. (1996) and Romero (1991). The relationship helps to eliminate any hindrance or obstruction in the flow of materials on the shop floor, thus facilitating smooth flow in the production line and hence making JIT implementation easier.

As far as the number of suppliers in the JIT system is concerned, it should be minimum and kept to one or two. It is difficult to maintain a close relationship with large number of suppliers because in this case confidentiality between the supplier and manufacturer will be adversely affected.

Effective Supply Chain

A supply chain is a network of linkages to connect suppliers, manufacturers and customers. It starts with the procurement of raw materials from the supplier and ends with finished goods reaching in the hands of customers. Everything in interconnected in the supply chain. Delay in one section will obstruct the following process and thus create an inventory problem which is against the spirit of the JIT system. To successfully implement the JIT system, the supply chain has to be very effective.

Elimination of Wasteful Activities

JIT requires all types of wasteful activities to be minimized or eliminated. Shigeo Shingo identified seven types of waste which need to be eliminated during JIT implementation. These seven wastes are connected to uneven production, non-utilization of equipment, non-rationalized transportation, defective processes, non-automation, fluctuative demand pattern and uneconomic motion (Hall, R; 1987). JIT has the potential to eliminate waste in production and material, (Tesfay, 1990).

Preventive Maintenance

The JIT system is based on the continuous flow of materials in the production line. Any machine breakdown or failure will lead to the piling up of inventory and obstruct the flow line of materials. Routine preventive maintenance can reduce the frequency and duration of machine down time (Krajewski et. al 2000b).

Small Lot Sizes

The size of the inventory is critical in JIT implementation. Large size inventory is not conducive for the JIT environment. Small batch production is a key element of the JIT system since it reduces work in progress inventory and increases responsiveness and flexibility (Gonzalez-Benito, J et al. 2000; Goldhar and Sarker 1992 and Zhueng 1994). In fact, small lot size inventory gets

regularly consumed and ensures smooth production flow keeping pipeline inventory (WIP) to a minimum. It helps to cut lead time which ultimately ensures on-time delivery. Manufacturing facilities are optimally utilized with uniformly distributed items of the small lot size making scheduling operations easier.

Large Capital Requirement

One of the reasons for the success of JIT in Japan is its capacity to invest large capital, thus providing excess capacity and increased flexibility to meet customer requirements. But the resource constrained industries have the common problem of arrangement of capital, which lowers the spirit and enthusiasm.

Organizational Set-up

Before an organization enjoys the fruits of JIT, it must accept JIT as an organizational philosophy. JIT requires not only changes in the way a company handles inventory but also changes in its operating procedures, production system and above all its organizational culture. People's attitude to work in a new environment and the role of quality circle is important for JIT implementation (Bowman, 1991). Quality circle helps in improving the processes and services through changes in organizational set-up. People are encouraged to discuss organizational problems informally through quality circles, which helps the speedy redressal of the problems.

Automated Manufacturing Environment

Automation facilitates JIT implementation by reducing setup and changeover times. JIT works more effectively in a computer integrated manufacturing (CIM) environment and the successful JIT users were more willing to shift to process layout (Yasin and Wafa, 1994).

Research Methodology

The area around Delhi in India has plenty of industrial units covering manufacturing, pharmaceuticals, leather and others. A number of industries and companies located in Faridabad and Gurgaon of Haryana State of India were contacted telephonically and by post and their opinions were sought on the JIT system. In fact, Delhi itself has a large number of small and medium size industries. The purpose of this study is to find out about the awareness of the industries towards the JIT system and its implementation pattern.

The present study is based on two broad categories. In the first category, about 100 companies were chosen and they were sent a detailed questionnaire on the JIT system to know its status. In the second category, about 50 companies were contacted telephonically to know their views about the JIT system.

Those companies which were sent the detailed questionnaire on the JIT system seemed to be least bothered about answering the points asked in the questionnaire. A self-addressed envelope was sent to each and every company along with the questionnaire, but their non-reply raised several doubts and put a question mark on the very basic purpose of conducting such a study. Only 50% of these companies answered the questionnaires. This group had been using the JIT system for the last 1 to 2 years and was not reaping the fruits. Only some among them have just started realizing the benefits of JIT implementation.

The second category consisted of those industries that were contacted telephonically and informal discussions were held with them. Also some of the industries were visited and their case studies are included in the paper.

Hypotheses

Based on the above facts, the following research hypotheses are proposed.

H1: Industries that have no knowledge of the JIT system need to be pushed to increase their awareness about the system.

H2: Industries which have not been using the JIT system for long (1 or 2 years) and have not yet got any results from its implementation. This group must be encouraged to continue with the system for better results.

H3: Industries which have been using the JIT system for many years and are benefiting from its successful implementation. The experience of this group can inspire others to adopt the system.

Majority of the industries fall in the first category. These are small and medium size units and they do not want to undertake the extra risk of losing their present markets in the hope of increased market share in future out of JIT implementation.

Short term gains appear to be the motto of their business. JIT implementation requires strict managerial control and discipline among workers, which were found to be missing in these companies. These companies were not very enthusiastic about JIT implementation on account of their total ignorance about the JIT system.

Industries which are in the very initial phase of JIT implementation are facing many problems. Their suppliers were found to be unreliable and non-committal and they competed with the companies rather than cooperating with them. This attitude prevents building of close relationships between manufacturer and supplier and it makes the task of JIT implementation tougher. JIT requires more or less constant demand pattern which is a difficult proposition in the context of industries. People, on account of their low purchasing power, are unable to buy quality products which certainly cost more in the initial stages.

Companies falling in the third category are using the JIT system effectively and are realizing the benefits of its implementation. But the number of such companies are very few. These are very large size companies whose turnover is quite high and which have a global presence. They have a strong supplier-manufacturer relationship as required in the JIT system.

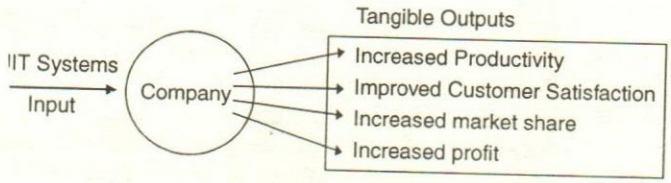


Fig. 1. Effect of JIT System on a Company.

Case Studies

The case studies of three leading companies are discussed below.

- UT Limited, Faridabad, Haryana (India), established in 1965, is a public limited company. It manufactures tractor hydraulics and elevators. It has been using JIT for the last one year and has found an increase of about 10% in its turnover since the implementation of JIT. The basic objective of using JIT is to reduce the size of inventory and the company has succeeded in reducing its inventory level between 10 to 15%. The customer is fully satisfied on account of significantly improved on-time delivery of finished products, made possible due to reduced lead time. The company has successfully reduced the wastage and has been able to launch new products well accepted by the market. As far as the environment for JIT implementation is concerned, it has penetrated in the minds of the management and workers and many of them are in favour of its successful implementation. Very few workers have left the company since JIT was implemented. Also a few people (about 5%) joined after JIT implementation. This low figure is not on account of lack of funds since implementation cost of

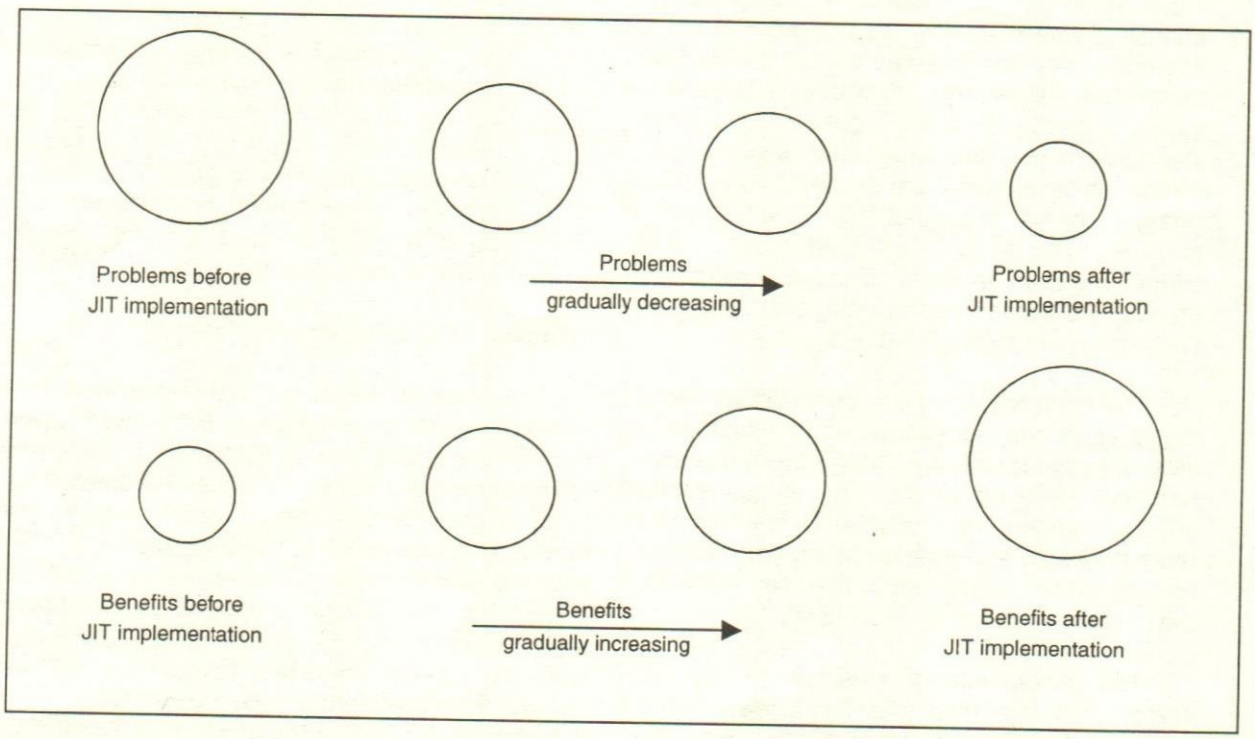


Fig. 2. Problems – Benefits relationship in a JIT System.

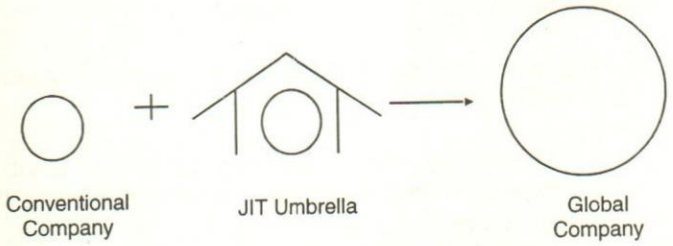


Fig. 3. Effect of JIT System on the size of a company

JIT up to beyond 10% of the total turnover of the company. Almost all sections including production, quality control and distribution, are connected through computers, which have probably helped the company in its effort to successfully implement JIT.

- Escorts JCB Limited, established in 1979, is a joint venture of JC Bamford Excavators Limited of U.K. One of the world's largest manufacturers of earthmoving, agricultural and materials handling equipment, its products are sold in over 150 countries, and Escorts Limited, one of India's leading business houses, has its head office at Ballabgarh, Haryana (India).

  The company is involved in the manufacturing and marketing of construction and earthmoving equipment and is the fastest growing company for its products, with an amazing annual growth of over 45%. It is an ISO 9001 accredited company with a network of over 140 dealership outlets and 21 offices. It manufactures its products to the highest international standards and at the same time ensures customer satisfaction of the highest order. The company boasts of several firsts – the first company to bring in Backhoe loaders and Telescopic handlers to India, as also the first to market and service earthmoving and construction equipment through a dealer network.

  The company has been using JIT for more than 2 years and has succeeded in reducing the level of inventory by more than 20%. It has also reduced waste up to 5%. After implementing JIT, the company has reduced its lead time by more than 20% and as a result, on-time delivery has improved significantly, thereby satisfying the customers to a maximum level.

  The implementation cost of JIT for the company is less than 5%. The company has successfully implemented JIT which is reflected in increased worker satisfaction. Although the company rates its vendors overall reliability as very high (around 95%), at the same time it feels that the selection of proper suppliers is one of the major hindrances in the implementation of JIT. The company has almost a monopoly in the products it manufactures and has already introduced a variety of related products in the market even before implementing JIT, and hence the company has not found much change after JIT implementation. The average changeover time for the new product is in hours. The company has successfully kept its machine downtime very low (up to 5%) and the usual time for transportation of goods from industry to customer is days and not weeks. It is using product layout and majority of the decisions are taken by top-level management.

- Clutch Auto Limited, Faridabad, Haryana (India) is a public limited automobile industry established in 1971. It is India's largest clutch manufacturer and exports its products to many countries including developed ones. In India, its products are used by Telco, Mahindra, Escort, Eicher, Maruti, Bajaj and Ashok Leyland and Defence establishments. Although it is an old company and has already accredited with QS 9000 and ISO 9001 Certification, it still does not use JIT. Decision making is largely confined to top-level management but customers feedback are also given weightage in the process of improving the existing products and developing new products. The average machine downtime is very low (about 5%) which helps the company to send its products quickly to customers. Almost every section is computerized and the company has been largely benefitted in new product development on account of computerization. Increased on-time delivery has satisfied the customers to a maximum level.

Conclusion and Recommendations

Industries have probably not understood the importance of time as emphasized by Benjamin Franklin in his book 'Advice to a Young Trademan' in which he says "Time is money and do not squander time". Due to increased globalisation, the industries need to be more competitive if they wish to survive in the market. They are required to keep away with their existing old fashioned practices of manufacturing and look forward to making their presence felt in the global market. Just-in-time (JIT) is such a concept which has the potential to change the outlook of the production system and may prove extremely beneficial in realizing the concept of global player. JIT is a recent concept and Japanese industries have proved

its worth. They have achieved global presence because of successful implementation of JIT.

Some industries seem not to be very enthusiastic about implementing JIT. They claim that the JIT system is not suitable for them and are of the opinion that JIT can only work effectively for the automobile industries. As the purpose of the present study is to find out the status of JIT implementation for industries, it has emphasized on the reason for lack of awareness about the JIT system. A fear or uncertainty regarding the consequences of JIT implementation was found to exist in the minds of industries. This fear has prevented them from fully understanding the JIT system.

It was thought initially that capital requirement may prove to be one of the obstructions in the way of JIT implementation but it was very surprising to note that this factor was not analyzed deeply by some of the industries.

The industries were found to be very uncertain about their suppliers. They were not ready to rely upon the suppliers on account of a lack of a close working relationship with them. In fact, suppliers were not found to be honest in delivering the items on demand and took a long time in meeting industries obligations.

Lack of communication linkages and uncertain demand pattern of the market aggravate the problems for industries.

It is recommended to increase the awareness about the JIT system among the management and the workers by imparting proper training. For that workshops and seminars may be organized. These facilities should be arranged regularly and frequently to sustain interest in the subject. Efforts must be made to realize the possible benefits of JIT implementation.

References

Besterfield, et. al (2001), "Total Quality Management, Pearson Education", Singapore.

Bowman, D.J. (1991), "If you don't understand JIT, how can you implement it? (JIT)", Industrial Engineering, Vol. 23, No. 2, pp. 38-40.

Golhar, D.Y. and Sarker, B.R. (1992), "Economic manufacturing quantity in a Just-in-time delivery System", International Journal of Production Research, 30, pp. 961-972.

Gonzalez-Benito, J; and Suarez-Gonzalez, I. (2001), "Effect of organizational variables in JIT purchasing implementation", International Journal of Production Research, Vol. 39, No. 10, pp. 2231-2249.

Hall, R. (1987) "Attaining Manufacturing Excellence", Homewood, Ill; Dow-Jones-Irwin, p-26.

Hobbs, O.K. Jr (1997), "Managing JIT toward maturity", Production and Inventory Management Journal, Vol. 38 No. 1, pp. 47-50.

Krajewski, L.J. and Ritzman, L.P. (2000), "Operations Management: Strategy and Analysis", Addison Wesley Longman, Singapore.

Lee, C.Y. (1996), "The applicability of just-in-time manufacturing to small manufacturing firms: an analysis", International Journal of Management, Vol. 13, No.2, pp. 249-58.

Romero, B.P. (1991), "The other side of JIT Supply Management", Production and Inventory Management Journal, Vol. 32 No. 4, pp. 1-3.

Tesfay, B. (1990), "Just-in-time eliminates waste", Personnel Management, Vol. 69 No. 1, pp. 81-2.

Vokurka, R.J. and Davis, R.A. (1996), "Just-in-time: The evolution of a philosophy", Production and Inventory Management Journal, Vol. 31 No. 2, pp. 57-59.

Vora, J.A. and Saraph, J.V. (1990), "JIT implementation practices", Production and Inventory Management Journal, Vol. 31 No. 3, pp. 57-9.

Wafa, M.A., Yasin, M.M. and Swinehart, K. (1996), "The impact of Supplier proximity on JIT success: an informational perspective", International Journal of Physical Distribution & Logistics Management, Vol. 26 No. 4, pp. 23-24.

Yasin, M.M. and Wafa M.A. (1994), "An empirical examination of factors influencing JIT success", International Journal of Operations and Production Management, Vol. 16, No. 1, pp. 23-24.

Zhuang, L (1994), "Toward a more economic production and Just-in-time delivery", International Journal of Production Economics, 36, pp. 307-313.

□

Your mind is like a parachute. It only works if it is open.

– Anthony J.D'Angelo

Feature

Perspectives of TQM in Indian industries

Raj Kumar, Dixit Garg & T.K. Garg

Indian companies have of late realized that the desired improvement in quality can be achieved if they understand not only what the various quality options are, but also the time when a particular approach should be applied. The present research deals with a quality improvement technique, Total Quality Management (TQM), in the Indian industry. Thirty factors relating to TQM have been discussed with the help of data collected from some ISO-certified industries. This has helped us to understand the present position of quality management programmes run by these industries.

Raj Kumar is lecturer at Shri Krishan Institute of Engineering and Technology, Kurukshetra; Dixit Garg is Assistant Professor, National Institute of Technology, Kurukshetra; and T. K. Garg is Professor, National Institute of Technology, Kurukshetra.

Ever since the Japanese companies demonstrated the competitive power of superior manufacturing by the global dominance of several industries, notably consumer electronics and automobiles, manufacturers worldwide were quick to realize the importance of the manufacturing excellence of superior products and services. By rapid development of technologies, processes and practices for attaining manufacturing superiority, the United States succeeded in neutralizing and even surpassing the great Japanese advantage. There is a general belief that manufacturing in India has suffered from lack of competitive focus for a long time and absence of strategic management. India can best be explained with reference to the four stage model of evolution of manufacturing, namely internally neutral, externally neutral, internally supportive and externally supportive. In India, manufacturing belongs to stage I or stage II. This means little strategic emphasis.

Indian companies are now trying to use various practices to reengineer their manufacturing processes to produce what the customer wants. For that they will have to wipe out their poor image of quality with the help of some quality management experts from Japan, America etc. At this point Dr. Ishikawa of Mushashi Institute of Technology, Tokyo, added a new dimension to this effect by involving task performers at the grassroot level to work towards quality improvement.

In India, a survey has been conducted which throws some light on the competitiveness of Indian industries and this survey also shows the various techniques used by our industries to maintain quality in their products (M.G. Korgaonker, 2000). These techniques can be divided into three broad categories as shown in Fig. 1 (Raj Kumar et al, 2002a).

In the 1990s, several success stories of Japanese and American manufacturing sector motivated Indian industries to implement total quality management (TQM) practices. However, many studies have indicated that the implementation of TQM quality techniques in India is much tougher than was realised. Management commit-

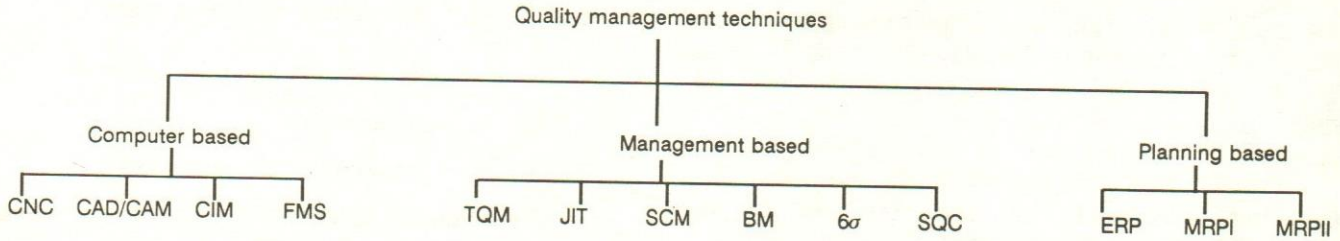


Fig. 1

CNC – Computerised numerical control
CIM – Computer integrated manufacturing
TQM – Total quality management
SCM – Supply chain management
6σ – Six sigma
ERP – Enterprise resource planning
MRPII – Manufacturing resource planning
CAD/CAM – Computer aided design/ manufacturing
FMS – Flexible manufacturing system
JIT – Just in time
BM – Bench marking.
SQC – Statistical quality control
MRP1 – Material requirement planning

ment, employee involvement, customer focus and satisfaction, continuous improvement etc. are essential for successful implementation of TQM.

Quality is everyone's responsibility and this thinking will develop by understanding, involvement and training. Total quality management is a practice to change the mindset for better understanding, to involve everyone from top to bottom, to train people for continuous improvement. The Confederation of Indian Industry (CII) in its introductory document "Total quality management – an introduction", defined TQM as meeting the requirements of the internal and external customers consistently by continuous improvement in the quality of work of all employees. TQM can be conceptualized into the following three processes: Quality process, Management process and People process.

Past studies

Past studies have revealed that many different slogans, catch words and acronyms have been used to refer to the philosophy of TQM including employee involvement, continuous improvement, kaizen, management commitment, self-directed work groups etc. TQM is looked on as a process-oriented philosophy of enhancing customer satisfaction through production of higher quality goods and services. Quality management practices of the past, however, were regarded as "after the fact" control techniques to detect defective items that required reworking. Hence past practices focus on quality control rather than quality management. TQM can be viewed as an organizational wide philosophy requiring all employees at every level of an organization to focus their efforts to help improve business activities of the organization (I.M. Silos, 1999). Much has been written about TQM but no systematic attempt has been made to define the critical elements of TQM implementation. TQM culture in Tata Engineering Jamshedpur put forward the fact that quality is no longer an isolated and independent function confined to the domain of the quality professional only, but that it has spread from the corporate boardroom to become an essential requirement of all (A.P. Arya, 2000).

Workers and managers, including the top management, are crucial elements in impacting change. Case studies of various Indian companies have revealed the fact that TQM cannot be implemented without employee empowerment of individuals, teams and organizations, management commitment, reward and recognition, management quality tools, small group activities, continuous improvement, customer focus and satisfaction, feed back system, training just in time, business process reengineering, quality function deployment, bench marking, total productive maintenance etc. (Raj Kumar et al, 2002b). Quality management is an independent procedure that is well defined, universal and documented and is arrived at through international consensus and sound management practice. These systems lead to improvements in products and services, where compliance is verified periodically. TQM is like following a philosophy of involving all employees in the effort to continually improve processes through committed team work and thereby provide integrated suppliers and customers, procedures and work instructions. TQM is a culture where people realize that the process of improvement is continuous. Literature survey also revealed a few causes which create some problems to Indian industries in adopting TQM. The causes are lack of customer focus, management commitment, training, cost and benefit analysis, rewards and recognition etc.

Indian industries facing the challenges of globalization, are trying hard to prove their competitiveness and are applying many quality management techniques to stay in the race. A few Indian industries that have adopted TQM as quality management techniques

successfully are: Arvind mills, Gujrat Ambuja, IFB, Indal, Mukand ltd. Oberoi ltd., Ranbaxy, Thermax, TI cycles and Vysya bank (A Kazmi, 1998; R.S. Dalu, 2000; D.I. Prajogo).

A survey has been carried out to see how Indian industries understand TQM and how they are implementing it. The main objectives of this study are:

- To identify different elements of a TQM system in manufacturing.
- To assess the need, adequacy, capability and potential of Indian industries to develop TQM approach.
- To identify various important factors used in Indian industries for TQM implementation.
- To conduct a comparative analysis of factors responsible for TQM implementation.

Methodology

A structured questionnaire-based survey and open interviews with managers and quality improvement officials of various industries have been used as a technique for data collection. The questionnaire covers companies' introduction (Product management, turnover, total manpower from top to bottom), quality policy, mission statement, status of TQM, importance of 30 factors in TQM implementation, detailed discussion on ten groups covering all the factors. The data was collected in two phases. In the first phase quantitative data was collected through the formed survey method and in the second phase qualitative data has been elicited through personal interviews and observations. The questionnaire was sent to 150 industries covering Haryana, Punjab, Delhi and Himachal Pradesh and out of these 52 responses were received. Then managers of 23 industries were personally interviewed once and then regularly contacted through e-mail to get useful and required information. A total of 75 responses were examined completely. All the industries contacted were selected through the criteria of ISO 9000 accreditation certification and with the help of list of companies under BIS. Table 1 gives the general profile of the industries.

Mission Statement

One of the essential features of strategic business planning is the formulation of a mission statement. A mission statement is a pattern of words which encapsulate a vision of the success and future directions of an organization. Webster Dictionary defines "mission statement" as an allotted self-imposed duty or task. Some of the major objectives of mission statement are:

- Unanimity of purpose within organization
- Continuous motivation
- Standard for organization resources
- Translation of objectives and goals.

Table 1: Respondent industries.

Sr.	Industry	R. No. / A. No.	% age responses	Products manufactured
1	Textile	23 / (35)	65	Yarn
2	Automobile	25 / (50)	50	2 wheeler, 3 wheeler, 4 wheeler, Heavy vehicles
3	Electrical & Electronics	12 / (25)	48	Electrical appliances, electronic goods
4	Chemical Engineering	5 / (20)	25	Various chemicals
5	Heavy Engineering	5 / (10)	50	Heavy engineering Works
6	Light Engineering	5 / (10)	50	Light engineering Works

* Turnover (in crores) from 200 to 3000
* Number of employees from 50 to 6415
N – Total number of respondent industries.
A. No – Actual number of industries to which questionnaire was sent.
R.No. – Response of industries.

Only 60 per cent industries have developed their separate mission statement. Others either have not developed a separate mission statement or use their quality policy for this purpose. Table 2 contains the various common factors as mission statement in various industries (See figure 2).

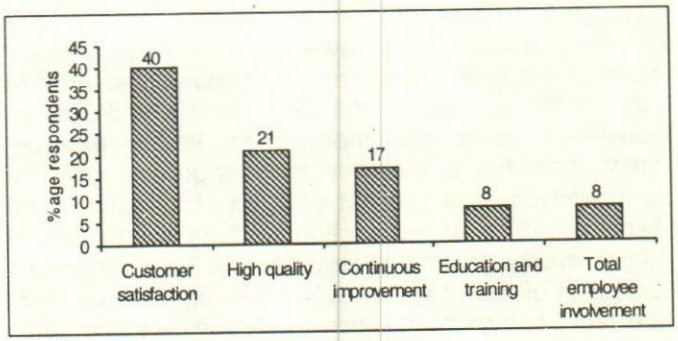


Fig. 2. Mission statement in percentage used by respondent industries

Quality policy

In support of the mission statement is the need for a quality policy. The quality policy expounds upon the principles contained within the mission. It fosters a shift

Table 2: Mission statement (N = 45)

Sr.	Industries	Respondent No. (%age)	Common objectives				
			Customer satisfaction No. (%age)	High quality product No. (%age)	Continuous improvement No. (%age)	Education & Training No. (%age)	Total employee No. (%age)
1	Automobile	16 (35)	8 (50)	4 (25)	3 (19)	-	1 (6)
2	Textile	14 (31)	4 (29)	4 (29)	3 (21)	2 (14)	1 (7)
3	Electrical & Electronics	7 (15)	2 (29)	2 (29)	1 (14)	1 (14)	1 (14)
4	Chemical	3 (6)	2 (67)	1 (33)	-	-	-
5	Heavy	3 (6)	-	1 (33)	1 (33)	1 (33)	-
6	Light	2 (4.4)	2 (100)	-	-	-	-

N – Total number of respondent industries.
No. – Number of specific industries

Table 3: Quality policy (N = 75)

Sr.	Industries	Respondent No.	Common objectives					
			Customer satisfaction No. (%age)	Continuous improvement No. (%age)	Training No. (%age)	High productivity No. (%age)	High quality No. (%age	Employee involvement No. (%age)
1	Automobile	25	10 (40)	6 (24)	4 (16)	3 (12)	-	2 (8)
2	Textile	23	9 (39)	4 (17)	4 (19)	2 (9)	1 (4)	4 (17)
3	Electrical & Electronics	12	4 (33)	3 (25)	2 (16)	1 (8)	1 (8)	1 (8)
4	Chemical	5	2 (40)	2 (40)	1 (20)	-	-	-
5	Heavy	5	-	2 (40)	1 (20)	-	1 (20)	1 (20)
6	Light	5	3 (60)	2 (40)	-	-	-	-

N – Total number of respondent industries.
No. – Number of specific industries

of emphasis from control and inspection of a product or service to error prevention. The policy also serves to heighten sensitivity to customer requirement and introduces the idea of shared responsibilities for providing a first class product or service. Management has a wide role in making and implementing the quality policy. The quality policy must be publicized and understood at all levels of the organization. Table 3 indicates some of the major components of the quality policies scanned during the study (See figure 3).

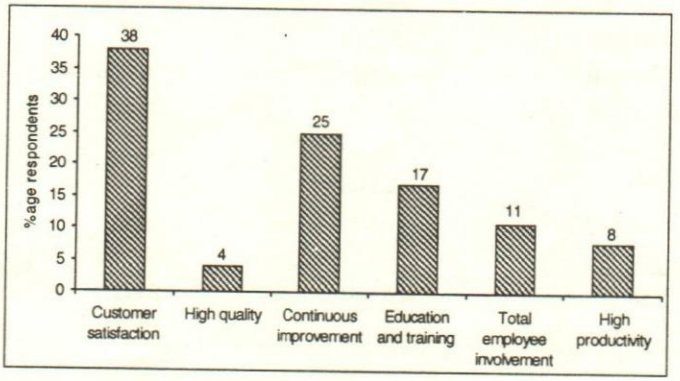


Fig. 3. Quality policy in percentage used by respondent industries

Survey Analysis

Group I: Management commitment and control covers the determinants which deal with employees of the company and it is found that maximum firms are taking employee as a participative member. Table 4 indicates that total employee involvement (70%), employee empowerment (67%), small group activity (53%), quality circle (47%), team work (56%), suggestion scheme (44%) and education and training (60%) are 'very important' and 'important' factors of TQM. Table 5 gives the ranking of industries covering group 1. Industries pertaining to electrical and electronics got 1st rank, textile 2nd, chemical 3rd and light engineering, automobile, heavy engineering got 4th, 5th and 6th rank respectively.

Group II: It deals with the field which fall under the control of management directly like top management leadership (92%), continuous improvement (56%) and

Table 4: Indicates the determinants of TQM group wise. (N=75)

Sr.	Determinants	Very imp. No. (%age)	Imp. No. (%age)	Not so imp. No. (%age)	Least imp.No. (%age)
1. Group – I					
(a)	Total employee involvement	52 (70)	18 (24)	5 (6)	-
(b)	Employee empowerment	20 (27)	50 (67)	2 (3)	2 (3)
(c)	Small group activity	25 (33)	40 (53)	6 (8)	4 (6)
(d)	Quality circle	26 (35)	35 (47)	11 (14)	3 (4)
(e)	Team work	42 (56)	25 (33)	8 (11)	-
(f)	Suggestion scheme	19 (25)	33 (44)	19 (25)	4 (6)
(g)	Education & Training	45 (60)	28 (38)	1 (1)	1 (1)
2. Group – II					
(a)	Top management leadership & commitment	69 (92)	6 (8)	-	-
(b)	Continuous improvement	38 (51)	25 (33)	10 (13)	2 (3)
(c)	Working environment	45 (60)	28 (38)	1 (1)	1 (1)
(d)	Seven management tools	5 (7)	42 (56)	24 (32)	4 (5)
3. Group – III					
(a)	Customer focus and satisfaction	69 (92)	4 (5)	2 (3)	-
4. Group – IV					
(a)	Recognition & awards	18 (24)	39 (52)	18 (24)	
5. Group – V					
(a)	Feed back system	32 (43)	29 (39)	11 (14)	3 (4)
6. Group – VI					
(a)	Vendor development	21 (28)	44 (59)	9 (12)	1 (1)
7. Group – VII					
(a)	Statistical process control	27 (36)	42 (36)	6 (8)	-
(b)	Daily process management	19 (25)	32 (43)	21 (28)	3 (4)
(c)	Seven quality tools	22 (30)	44 (58)	9 (12)	-
(d)	Taguchi method	15 (20)	15 (20)	20 (27)	9 (12)
(e)	Zero defect	15 (20)	34 (45)	18 (24)	8 (11)
8. Group – VIII					
(a)	Just in time and waste elimination	15 (20)	49 (53)	12 (16)	8 (11)
(b)	Business process re-engineering	23 (31)	35 (47)	12 (16)	5 (6)
(c)	Benchmarking	11 (14)	37 (49)	24 (33)	3 (4)
(d)	House keeping	25 (47)	31 (42)	8 (11)	-
(e)	Quality function deployment	19 (25)	33 (44)	4 (6)	19 (25)
(f)	Total preventive maintenance	19 (26)	37 (49)	12 (16)	7 (9)
9. Group – IX					
(a)	Quality process planning	24 (32)	35 (47)	12 (15)	4 (6)
(b)	Cost of quality	15 (20)	37 (49)	19 (25)	4 (6)
10. Group – X					
(a)	Design of experiment	7 (10)	28 (37)	20 (27)	20 (27)
(b)	Failure mode analysis	10 (13)	29 (39)	19 (25)	17 (23)

N – Total number of respondeent industries.
No. – Number of specific industries

all these lie in 'very important' and 'important' category. Approximately 3 to 13% of industries do not care for continuous improvement and approximately 30 per cent of companies do not take management tools very seriously. But management leadership and working environment are the 'important' factors of TQM (Table 4). Ranking of the industries for group II is 1st chemical, 2nd textile, 3rd automobile and light engineering., electrical and electronics and heavy engineering remains at 4th, 5th and 6th respectively (Table 5).

Table 5: Ranking of industries in groups

Industries/Group	1	2	3	4	5	6	7	8	9	10
Automobile	V	VI	II	V	VI	IV	II	IV	IV	II
Textile	II	II	I	III	IV	III	I	I	III	I
Electrical & Electronics	I	V	III	I	VI	II	IV	V	III	III
High Engineering	VI	VI	IV	VI	V	V	II	II	II	II
Light Engineering	IV	IV	IV	IV	II	I	III	II	I	VI
Chemical Engineering	III	I	I	II	I	VI	V	III	III	IV

Group III: It puts its emphasis only on customer focus and satisfaction and 92 per cent of industries believe that the customer is the key to the market. The more the customer is satisfied the more the chances of survival in the global market. Only three per cent of industries have different views on this point. Textile industries and chemical industries are sharing the number one position, automobile the 2nd, electrical and electronics the 3rd and Heavy and Light industries share the fourth rank (Table 5).

Group IV: Most of the respondent companies feel that people like recognition either as a team or individually. Recognition does not mean money. A person's feeling of value, knowing the organization cares, and having peer recognition may be more important than money. Fifty two per cent industries grade group IV as 'important' (Table 4). Ranking in group is electrical and electronics, chemical, textile, light engineering automobile and heavy engineering (Table 5).

Group V: A successful organization requires feedback from several directions from one's leader, the press and people who report to you. This is some times called 360° feedback system. An effective mechanism is a very important element of a successful TQM programme (Table 4). But only 43 per cent industries consider it as 'very important' and 39 per cent as an 'important' factor. Four to 14 per cent of industries are still taking it as 'not so important' or 'least important'. Chemical industries ranked 1st in group, light engineering 2nd, automobile 3rd, and textile, heavy and electrical and electronics at 4th, 5th, and 6th respectively (Table 5).

Group VI: Vendor quality programmes need to be developed in TQM activity. This is essential because total quality cannot be achieved in a vacuum. Some companies (59%) spend nearly two-thirds of their revenue on products and services that come from vendors (Table 4). There are only 1 to 12 per cent industries for which vendor development is a 'not so important' factor of TQM. Ranking in this group is light engineering 1st, electrical and electronics 2nd, textile 3rd, automobile 4th and heavy and chemical engineering industries at 5th and 6th rank (Table 5).

Group VII: It covers the control process for total quality management like strategically process control, daily process managements, seven quality tools and zero defects. This group mathematically helps industries to reduce defects and increase the acceptable products. Fifty per cent industries take it as 'important' and only three to nine per cent do not consider it as an important factor for TQM (Table 4). Textile industries consider it very important so it is at rank 1st, 2nd rank was shared by automobile and heavy engineering, light engineering at 3rd and electrical and electronics and chemical engineering industries at 4th and 5th respectively (table 5).

Group VIII: It is a well known that TQM is a time-consuming process as it has to change the previous mindsets. But industries are using some other techniques to get faster and better results. Group VII deals with such processes like just in time, business process reengineering, bench marking, housekeeping, quality function deployment and total productive maintenance, but the number of such industries is as small as 20 per cent. Industries (Table 4) take it as a 'very important' factor. Rank-wise textile is 1st, light engineering and heavy engineering 2nd, chemical 3rd, and automobile, electrical and electronics are at 4th and 5th rank respectively (Table 5).

Group IX: It covers the cost of quality through quality process planning and cost of quality but only 32 to 49 per cent industries take it as 'very important' or 'important' and 27 per cent do not consider it as an 'important' factor for TQM (Table 4). Light engineering at first, heavy engineering at 2nd, and textile, electrical and electronics and chemical at 3rd and automobile at 4th is the ranking of industries in this group (Table 5).

Group X: It covers design of experiment and failure mode and effect analysis which are to be considered as

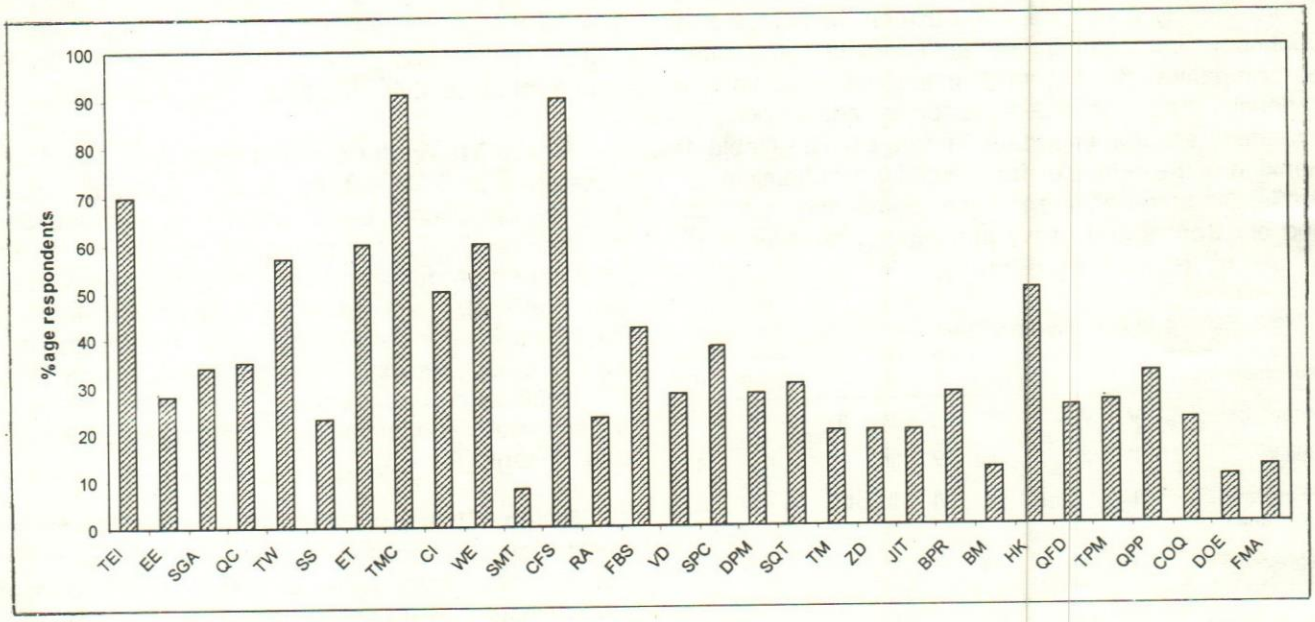


Fig. 4. Importance of various factors on the basis of 'very important'

'important factors' of TQM but unfortunately only 19 per cent consider it as 'important' and others consider it as a 'not so important' factor of TQM (Table 4). Textile is at 1st, automobile and heavy engineering at 2nd, electrical and electronics at third and chemical and light engineering are at 4th and 5th ranking in this group (Table 5).

Fig. 4 clearly shows the importance of factors in Indian industries.

Conclusion and scope for future work

The Total Quality Management (TQM) concept is being implemented and practiced in many companies. It is an attempt to bridge the existing research gap. This study will be of great benefit to respondent companies and numerous other companies who are in the process of implementing TQM.

The major findings of the study are as follows:

(1) Most of the respondent companies believe in the philosophy of TQM. Customer satisfaction, continuous improvement, and total employee involvement are some major objectives of TQM.

(2) Sixty per cent industries have developed their separate mission statements. Others use their quality policy for this purpose. Some major elements of their quality policy are customer satisfaction, high product quality, leadership, education and training etc.

(3) Majority of respondent companies consider top management leadership and commitment, continuous improvement, customer satisfaction, participative work culture, education and training, statistical process control, business process reengineering, benchmarking, just in time and transparent communication system as very important factors in TQM implementation.

(4) Total employee involvement (70%), top management leadership and commitment (92%), customer focus and satisfaction (92%) seem to be important determinants of total quality management.

From the above findings and survey analysis one can conclude that the Indian companies in general are in favour of implementing TQM in their environments. They have understood the concept and relevance of TQM. Though their attitude is positive, yet TQM in Indian industries suffers from certain limitations. Different companies give priority to different factors which can be seen very clearly from ranking of different industries in different groups (Table 5). In future studies a model can be developed for industries so that they can understand and implement TQM principles easily. The relevance of the results or findings can be checked through case studies in some firms, and that model can help a lot in the study.

References

Ahire, S. L. (1996), "TQM age versus quality: An empirical investiga-

tion", Production and Inventory management journal 1st quarter.

Arya, A.P. (2000), "Fostering TQM Culture in Tata Engineering Jamshedpur", Industrial Engg. Journal, vol.29 no-10, Oct .

Chaudhry, P.E. et al. (2000), "Managerial perceptions of quality control in Japanese business", Production and Inventory Management journal 4th quarter .

Dalu, R.S. et al. (2000), "An exploratory study of quality management practices in small and medium scale inventory", Industry Engg. Journals vol.29 no.12 Dec.

Ghobadian, A. (2001), "TQM implementation: an empirical examination and proposed generic model", Omega The International journal of management science, Omega 29.

HO, S.K.M. (1999), "From TQM to business excellence", Production Planning and Control, vol. 10 no.1.

Karthikeyan, G. (1990), "Implementation Implication of TQM practices in manufacturing companies: Some Indian experiences", Vol. 5 no.4

Kazmi, A. (1998) "Where TQM works: Successful experiences in Indian companies", Vol.5 no.4.

Keswani, I.P. et al. (1996), "Quality engineering using taguchi techniques – a case study", Productivity vol.37 no.2 July-Sept.

Korgaonker, M.G. (2000), "Competitiveness of Indian manufacturing enterprises", MM Dec.

Kumwiede, D.W. et al. "Understanding the Relationship of Top Management Personality to TQM Implementation", Production and Inventory Management 2nd.

Mohanty, R.P. (1997) "TQM: some issues for deliberation", Production planning and control. Vol.8 no.1.

Nirmala, S. (1998), "Making TQM work – some critical issues", Productivity. Vol.39 no.2 July-Sept.

Oiker, L.R. (1992), "Total quality management: A case analysis", *Productivity vol.33 no.3 Oct-Dec.*

Prajogo, D. I et al. "Applying the TQM philosophy and tools for managing innovation: An Australian case study", Intl. Conf. On mgmt. of R&D Dept. of mgmt. studies IIT Delhi.

Rajkumar et al. (2002), "Quality management practices in Indian Industries", Productivity vol.43 no.3 Oct-Dec.

Silos, I.M. (1999), "Employee involvement – a component of total quality management", Production and inventory manage ment journal – first quater.

Tatikonda, L. U. (1996), "Top ten reason your TQM effort is failing to improve profit", Production and Inventory management 3rd quarter.

Zairi, M. (1995), "Benchmarking in R&D", Productivity. Vol. 36 no.3 Oct-Dec.

□

What you need is a fundamental humility – the belief that you can learn from anyone.

– Clayton Christensen

Feature

Simulated Annealing Algorithm for Mixed-Model U-shaped Line Balancing Problem

K. Venkatasubbaiah & T.S.A. Surya Kumari

The mixed-model approach is more realistic in the modern world. With the growing trend for greater product variability and shorter life cycles, they are replacing the single model lines. The production line considered in this paper is a U-shaped line where assembly tasks are performed to produce a variety of different discrete models in a just-in-time (JIT) environment. The mixed-model U-line balancing (MMULB) problem assigns the tasks required to produce all models to a minimum number of stations on a U-shaped line. Simulated Annealing algorithm is presented to solve the MMULB problem and results are reported.

K.Venkatasubbaiah & T.S.A. Surya Kumari are with Mechanical Engg. Department, Andhra University, Visakhapatnam.

In early days of automation, high productivity was achieved in mass production assembly systems by designing and balancing dedicated assembly lines for a single product. The balancing problem was studied extensively for single models and is generally known as the 'Single model assembly line balancing problem'. When building and maintaining of an assembly line are costlier, product variety demands are high and production with small lot sizes are required, then assembly lines are operated as mixed-model lines. The mixed-model U-line balancing problem is the recent approach in various industries as a consequence of implementing just-in-time (JIT) principles and negligible set-up times. In mixed-model production, different products or models are interspersed throughout a production sequence. This helps manufacturers provide their customers with a variety of products in a timely and cost-effective manner. Two important problems occur routinely with these lines:-

1. The mixed-model line-balancing problem.
2. The mixed-model sequencing problem.

This paper presents the simulated Annealing algorithm for solving the mixed-model line-balancing problem, when the production line is U-shaped and production follows just-in-time (JIT) principles.

The first researcher who constructed a mathematical model of the assembly line balancing problem and suggested a solution procedure was Salveson (1955). Later, numerous optimum-seeking algorithms and heuristics that attempt to solve different versions of the problem have been developed. The results of a comprehensive review and analysis of the assembly line balancing literature was reported by Ghosh and Gagnon (1989). Various concepts of mixed-model line balancing problem were given by Erel and Gokcen (1999) and others. Various optimizing algorithms of U-line balancing problems are discussed in the works of Miltenburg and Wijngaard

(1994), and Scoll and Klein (1999). The mixed-model sequencing problem (for U-lines) in JIT production system is analysed in Miltenburg and Goldstein (1991). The mixed-model U-line balancing problem is presented by Sparling and Miltenburg (1998). A new approach to solve difficult combinational optimization problems known as "Simulated Annealing" algorithm is presented in McMullen and Frazier (1998). The nature of mixed-model production presents additional challenges for line balancing compared to single-model production. In this paper, solution for MMULB problem is obtained by using a simulated annealing algorithm.

Notations:

- x: index of test ($1 \le x \le X$)
- n: Index of model ($1 \le n \le N$)
- m: Index for station ($1 \le m \le M$)
- $t_{n,x}$: Task processing time for task x on model n
- $l_{n,x}$: Travel distance for task x on model n
- g: Time required to travel one unit of travel distance
- d_n: Number of units of model n produced during the planning period
- DT_m: Total travel distance in the station m
- $[f,b]_m$: A model mix at station m, i.e., models f and b produced at the front and back, respectively of station m.
- ST_m: Set of tasks at station m

Formulation of the Mixed-model U-line balancing problem

The mixed-model version of the problem is transformed into a single-model version with a combined precedence diagram. Precedence requirements of the different models are reflected in a combined precedence diagram. Because the tasks, task completion times and precedence constraints vary from model to model in the mixed-model problem, some assumptions are made (1) Common tasks between the models exist and these are assigned to the same workstations. (2) Precedence constraints are consistent from model to model. That is, if task x precedes task y in any model there is no other model where task y must precede task x. (3) The same balance is used for all models. Tasks are not assigned to different stations for different models.

The mixed-model U-line balancing problem is defined as follows:

Given set of tasks

$$S = \{x/x = 1,2...x\},$$

Given number of models

$$N = \{n/n = 1,2...n\},$$

Deterministic demands of models

$$D = \{d_n//d_n = d_1, d_2, ..., d_n\},$$

A set of precedence constraints

$$P = \{(x,y)\backslash \text{task x must be completed task y}\},$$

A set of weighted average processing times

$$T = \{\bar{t}_x / \bar{t}_x = \bar{t}_1, \bar{t}_2, ...\},$$

A total travel distance in station m $\bar{DT_m}$,

A time required to travel one unit of travel distance g,

And a cycle time C.

The initial and final objectives of the problem are as follows:

$$\text{Minimize, } F_1 \sum_{m=1}^{M} \left(\left(\sum_{x \in ST_m} \bar{t}_x + g * DT_m \right) - C \right)^2 \quad (1)$$

$$\text{Minimize } F_2 = \sum_{m=1}^{M} ib_m \quad (2)$$

Subject to the following constraints:

$$\bigcup_{m=1}^{M} ST_M = S \quad (3)$$

$$ST_m \cap ST_{m^1} = \phi \text{ for all m} \quad (4)$$

$$\sum_{x \in ST_m} \bar{t}_x + g * DT_m \le C \text{ for all m} \quad (5)$$

for each task y $\in$ S

Either: if (x,y) $\in$ P, x $\in$ ST_m, y $\in$ ST_{m^1} then $m \le m^1$ for all x; (6)

Or: if (y,z) $\in$ P, y $\in$ ST_{m^1}, z $\in$ $ST_{m^{11}}$ then $m^{11} \le m_1^1$ for all z (7)

Condition (3) ensures that all tasks are assigned to a station. As a result of condition (4), each task is assigned only once. U-shaped line balancing problem does not permit tasks to be shared between stations. Condition (5) ensures that the sum of the weighted average task processing times and the travel time in each station does not exceed the cycle time. P, the combined precedence diagram is used in the constraint (6).

Conditions (6) and (7) together ensure that the precedence constraints are not violated on the mixed-model U-line.

Methodology

Solution algorithm of MMULB problem aims to minimise the number of stations for a required cycle time. The balancing procedure attempts initially to balance the U-line for the required cycle time to minimise the work balance among the workstations. Simulated Annealing algorithm is used to find the optimal solution. At the end of the balancing procedure model imbalance is calculated and reduced again using the Simulated Annealing algorithm and the procedure is completed with the obtained solution.

The following are the procedure steps of the MMULB problem.

Step 1: In this step initialise the total number of models, required demands of each model, the total number of tasks for each model, their task times, their precedence relations, travel distances of tasks for each model, time required to travel one unit of travel distance and cycle time.

Step 2: Calculate the weighted average processing times and weighted average travel distances for each task. Calculate the cycle time (if required).

Then weighted average processing time of task x is

$$\bar{t}_x = \frac{\sum_{n=1}^{N} t_{n,x}\, d_n}{\sum_{n=1}^{N} d_n}$$

And weighted average travel distance of task x is

$$T_x = \frac{\sum_{n=1}^{N} l_{n,x}\, d_n}{\sum_{n=1}^{N} d_n}$$

Step 3: Construct a combined precedence diagram by merging each model's precedence diagram to transform the mixed-model line-balancing problem into a single model version. Nodes and arcs on the combined precedence diagram represent tasks and precedence constraints between tasks, respectively. If, for any model, task x is an immediate predecessor for task y, and arc xy is added to the combined precedence diagram (if one does not already exist).

Step 4: Solve a single model U-line balancing problem with the average processing times from step 2 and combined precedence diagram from step 3. To obtain optimum solution Simulated Annealing algorithm is used.

a. Initialise the model by specifying a cycle time (C), a control parameter (T), a cooling rate (CR), a number of iterations for each level of T (N_{max}), and stopping criteria (T_{min}). The initial feasible solution for the problem is generated using random sequence generation of tasks. This initial solution becomes the first 'current' solution and the first 'best' solution used for the search technique. The objective function value for the current solution will be referred to as E_c, and the objective function value for the best solution will be referred to as E_b.

b. From the current solution, generate a feasible neighbouring solution. This is done via a trade or a transfer.

c. Calculate the difference between the objective function values of the test solution and the current solution. This difference will be referred to as the 'energy change', δE, and is calculated from the formula

$$\delta E = E_t - E_c.$$

If the value of the energy change is negative ($E_t < E_c$), proceed to step d. Otherwise, proceed to step e.

d. If $E_c < E_b$, then the best solution is replaced by the new current solution. Then proceed to step f.

e. Generate the Metropolis criterion for accepting a test solution with an objective function inferior to that of the current solution. This criterion provides the following probability of an inferior test solution being accepted as the current solution $P(a) = \exp(-\delta E/T)$.

Next, a uniformly distributed random number (Ran) from the interval (0, 1) is generated. If Ran < P(a), the inferior test solution being accepted as the current solution, and proceed to step f.

f. If the current iteration number (N) is equal to

the maximum number of iterations (N_{max}), then proceeds to step g. Otherwise, increment the iteration number (N) by 1 and return to step b.

g. Adjust the cooling temperature by using the following relationship, T = T *CR. If the new value of T is less than the stopping criteria (T_{min}), then proceed to step h. Otherwise, re-initialize the current iteration number (N) to 1, and return to step b.

h. The Simulated Annealing heuristic is completed. The optimal solution is that corresponding to the best solution, E_b.

Step 6: Call the solution obtained in the step 5 is the initial balance for the mixed-model U-line balancing problem and calculate the model imbalance. Obtained solution may be optimal for the average task processing times and combined precedence diagram, it may not even be feasible for individual models. When individual model times are considered in each station the required time exceeds the available time. This variation in station times is called model imbalance. Taking the obtained set of workstations from the initial balance for a given model sequence, model imbalance is calculated as follows;

- Calculate the total time for each cycle for each station considering the individual model task processing times.

  Total time for each cycle of station m for model mix $[f, b]_m$ is

$$TT\left([f, b]_m = \sum_{x \in ST_m} t_{f,x} + \sum_{x \in ST_m} t_{b,x} + g * DT_m\right)$$

- Calculate the target time for every station for every cycle. Usually the target is the cycle time, but other targets may also be used. So, the target time for the total time for station 'm' for each cycle is

$$G = \frac{1}{M}\left(\sum_{m=1 \text{ for all } [f,b]_m \text{ in } m}^{M} TT\left([f,b]_m\right)\right)$$

- Calculate the model imbalance. Model imbalance is the sum of the imbalances of all stations. Imbalance at each station can be determined as the sum of the differences between the total times and target times.

  Model imbalance is, $IB = \sum_{m=1}^{M} ib_m$

Step 7: To obtain the final solution of MMULB problem smooths the initial balance to reduce model imbalance. Taking model imbalance as an objective function and initial solution, cycle time as inputs find an optimal solution using simulated annealing algorithm, this is described in step 5.

Step 8: After completing Simulated Annealing heuristic, obtained best solution is the optimal solution for the mixed-model U-line balancing problem.

Illustrative Example

A simple example is presented, illustrating the application Simulated Annealing algorithm to address the mixed-model U-line balancing problem. Three models A, B and C are produced on a U-shaped assembly line, each at the rate of 25units/ planning period, i.e., $d_A = 25$, $d_B = 25$ and $d_C = 25$, running at a cycle time 1.7 time units/model. The data of the problem is given in the table 1.

Table 1: Data of the Problem

Task	Precedence Constraints			Processing times			Task Travel Distance
	A	B	C	A	B	C	
1				0.5	0	1.0	6
2				0.4	0.8	1.2	7
3				0	0.2	0.4	4
4				0.4	0	0	4
5				0.2	0.2	0.2	8
6	1			0.2	0	0	2
7	1,2	2	1,2	0.4	0.5	0.6	8
8		2	2	0	0.5	0.5	9
9	2	2,3	2,3	0.4	0.3	0.2	8
10			3	0	0	0.2	2
11	4,5	5	5	0.3	0.3	0.3	5
12	7	7,8	7,8	0.1	0.3	0.5	9
13	11		11	0.1	0	0.1	9
14	11	11	11	0.2	0.2	0.2	5
15	9,12	9,12	9,12	0.7	1.0	1.5	10
16		3,11		0	0.1	1.5	10
17	13	11		0.5	0.5	0	2
18	14	14	14	0.3	0.5	0.3	10
19	14,17	14,17		0.4	0.3	0	9

Table 2: Initial Mixed-Model U-Line Balance

Workstation (m)	1			2			3			4			5		
	{5, 2}, {16}			{8}, {15}			{1}, {6, 10, 19, 12}			{7}, {13, 17, 9}			{4, 3, 11, 14}, {18}		
Model Mix:	AA	BB	CC	AC	BA	CB	AB	AC	CA	BA	BC	CA	AC	BA	CB
Total Time:	0.744	1.244	1.544	1.614	1.314	1.614	1.268	1.368	1.868	1.662	0.962	1.762	1.368	1.168	1.568
Target Time:	1.331	1.211	1.671	1.331	1.211	1.671	1.331	1.211	1.671	1.331	1.211	1.671	1.331	1.211	1.671
Difference:	0.587	0.033	0.127	0.283	0.103	0.057	0.063	0.157	0.197	0.331	0.249	0.091	0.037	0.043	0.103
Imbalance:		0.747			0.443			0.417			0.671			0.183	
Total Imbalance:								2.461							

Table 3: Final Mixed-model U-Line Balance

Workstation (m)	1			2			3			4			5		
	{5, 2}, {16}			{8}, {15}			{1}, {6, 10, 19, 12}			{7}, {13, 17, 8}			{4, 3, 11, 14}, {9}		
Model Mix:	AA	BB	CC	AC	BA	CB	AB	AC	CA	BA	BC	CA	AC	BA	CB
Total Time:	0.744	1.244	1.544	1.614	1.314	1.614	1.268	1.368	1.868	1.574	0.962	1.762	1.256	1.256	1.356
Target Time:	1.291	1.251	1.611	1.291	1.251	1.611	1.291	1.251	1.671	1.291	1.251	1.611	1.291	1.251	1.611
Difference:	0.547	0.007	0.067	0.323	0.063	0.003	0.023	0.117	0.197	0.283	0.177	0.063	0.035	0.005	0.255
Imbalance:		0.622			0.388			0.397			0.523			0.295	
Total Imbalance:								2.225							

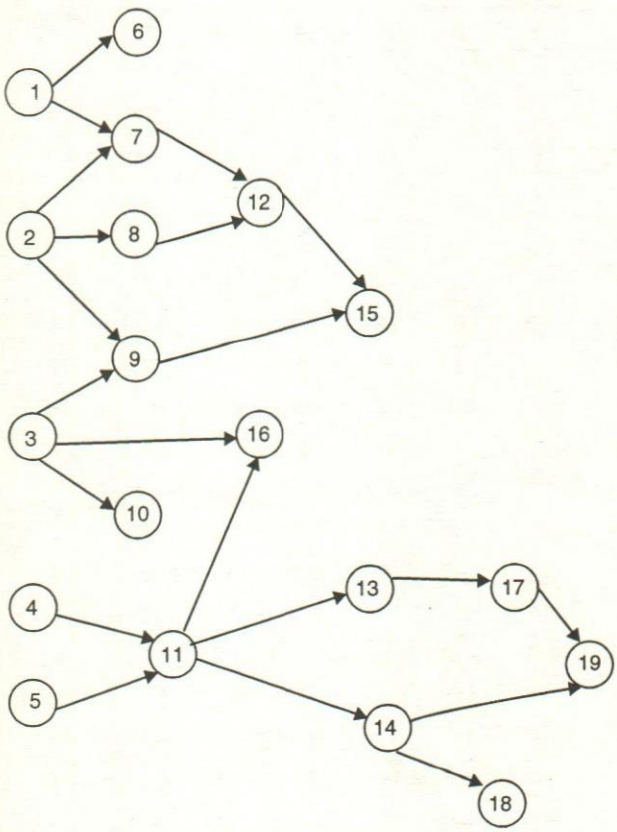


Fig. 1. Combined Precedence Diagram

To transform the three models into a single model, weighted average processing times and weighted average travel distances for each task are calculated. Figure 1 shows the combined precdence diagram of the three models: model A, model B and model C.

Optimal U-line balance is obtained by using SA algorithm and this is initial balance for mixed-model U-line balancing problem. Table 2 shows the initial balance of the MMULB problem. Using the Simulated Annealing parameters of an initial temperature of 50,000, a cooling rate of 95% and 50 iterations at each level of the temperature and the stopping criteria for temperature is taken as 10,000, final balance of MMULB problem is obtained and given in table 3.

Tables 2 and 3 give the results of proposed model.

Conclusions

In this paper, Simulated Annealing algorithm is developed for the initial and final balance of the mixed-model U-line balancing problem. Initial balance is obtained by minimising the workbalance among the workstations and the model imbalance is reduced for the final balance. From the Tables 2 and 3 it is observed that the proposed algorithm obtained better results. This work can be extended by solving line balancing and

model sequencing problems simultaneously for the effectiveness of a mixed-model U-line.

References

Ghosh, S. and Gagnon, R.J. (1989), "A comprehensive literature Review and Analysis of the Design, Balancing and Scheduling of Assembly Systems", International Journal of production Research, vol.27, no.4, pp 637-670.

Miltenburg, G.J. and Wijngaard, J. (1994), "The U-line balancing problem", Management Science, vol.40, no.10, pp 1378-1388.

Scholl, A. and Klein, R. (1999), "ULINO: optimally balancing U-shaped JIT assembly lines", International Journal of Production Research, vol.37, no.4, pp 721-736.

Miltenburg, J., and Goldstein, T. (1991), "Developing production schedules that balance part usage and smooth production loads for Just-in-time production systems", Naval Research Logistics, vol.38, pp 893-910.

Erdal Erel and Hadi Gokcen (1999),"Shortest-route formulation of mixed-model assembly line balancing problem", European Journal of Operational Research, vol.116, pp 194-204.

Sparling, D., and Miltenburg, J. (1998), "The mixed-model U-line balancing problem", International Journal of Production Research, vol.36, no.2, pp 485-501.

McMullen, P.R., Frazier, G.V. (1998), "Using Simulated Annealing to solve a multi-objective assembly line balancing problem with parallel workstations", International Journal of Production Research, vol.136, no.10, pp 2717-2741. □

A trutle travels only when it sticks its neck out.

– Korean proverb

Feature

Objectives in Single Machine Scheduling

Pankaj Chandna & S.K. Sharma

This paper analyses the gap between theoretical objectives and objectives used in practice for single machine scheduling environment. It aims to present a comprehensive review of objectives used, their limitations and to contrast the currently available objectives with those generally used. It has been concluded that most of the attention has been focused on NP-hard problems that lie close to the boundaries that separate NP-hard problems from polynomial time problems.

Pankaj Chandna is lecturer and S.K. Sharma is professor at NIT, Kurukshetra.

Scheduling is a decision-making process that plays an important role in most manufacturing and production systems as well as in most information processing environments. It deals with the allocation of scarce resources to tasks overtime. It is a process with the goal of optimizing one or more objectives. Objectives used in scheduling vary with the environment. Researchers have used both regular and non-regular and also multiple objectives for single machine scheduling in the past.

Single machine models are important for various reasons. The single machine environment is very simple and is a special case for all other environments. Single machine models often have properties that neither machines in parallel or machines in series have. The results that can be obtained for single machine models not only provide insights into the single machine environment, but also provide a basis for heuristics that are applicable to more complicated machine environments. In practice, scheduling problems in more complicated machine environments are often decomposed into subproblems, which deal with the single machines. For example, a complicated machine environment with a single bottleneck may give rise to a single machine model.

In this paper the author considers the gap between theoretical objectives and objectives used in practice. The development and the main results of the theoretical objectives used for single machine scheduling purpose are reviewed and categorized in an easily accessible way according to different environments.

Notations Used

w_j = weight of job j regarded basically priority factor i.e. denoting the importance of job j relative to the other jobs into the system.

C_j = time job j exists in the system (i.e. its completion time on the last machine on which it requires processing).

p_j = Processing time of job j on all m machine identical.

$prec$ = precedence constraints

L_{max} = maximum lateness i.e. max (L_1—L_n)

d_j = due date of job j represents the committed shipping or completion date.

r_j = release date of job j may also be referred to as the ready date.

T_j = tardiness of job j

U_j = unit penalty of job j

X_j = original random processing time of job j

$prmp.$ = preemption imply that it is not necessary to keep a job on a machine, once started, until completion.

Single machine models (Deterministic)

In most of the models in this environment, there is no advantage of having preemptions, for these it is shown that the optimal schedule in the class of preemptive schedules is non-preemptive. However, if the jobs are not all released at the same time in a pre-emptive environment, then it may be advantageous to have unforced idleness (i.e., there may not be an optimal schedule that is non-delay). The entire objective functions used in this environment are generally regular and that is why most of the models with these objective functions are relatively easy to solve.

The most commonly used objective function in the environment by the researchers is the total weighted completion time (i.e. $1||\sum w_j C_j$). The weight w_j of job j may be regarded as an importance factor; it may represent either a holding cost per unit time or value already added to job j. This problem gave one of the better-known rule in scheduling theory, the weighted shortest processing time first (WSPT) rule. According to this rule, the jobs are ordered in decreasing order of w_j/p_j. The optimality of the WSPT rules for $1||\sum w_j C_j$ appears in the seminal paper by Smith (1956). Lawler (1978), Monma and Sidney (1987) and Sidney and Steiner (1986), all present very elegant results for $1|prec|\sum w_j C_j$; the classes of precedence constraints considered in these papers are fairly general and include chains as well as intrees and outtrees.

Second category of the objectives considered is due-date related. The first measure is of general nature i.e. the maximum lateness namely $1|prec|h_{max}$ where

$$h_{max} = \max (h_j (C_1)),...h_n (G))$$

with h_j, $j = 1, 2.....n$, being non-decreasing cost functions.

The problem $1 || L_{max}$ is the best known special case of $1|prec|h_{max}$.. The function h_j is the defined as $C_j - d_j$, and the algorithm results in the schedule that orders the job in decreasing order of their due-dates (i.e. Earliest Due Date [EDD] first). The EDD rule is from Jackson (1955) and the algorithm for this has been given by Lawler (1973). A generalization of $1 || L_{max}$ is the problem $1 |r_j |L_{max}$ with the jobs released at different points in time. This generalization, which does not allow preemption, is significantly harder than the problem with all jobs available at the same time. The complexity proof of $1|r_j|L_{max}$ appears in Lenstra et al. (1977). McMohan & Florian (1975), Carlier (1982) have worked on branch and bound methods for the above problem. Potts (1980) analyzed a heuristic for the same.

Another due-date related objective is $\sum U_j$.. This objective may at first appear somewhat artificial and of no practical interest. However in the real world, it is a performance measure that is often monitored and relative to which managers are measured. It is equivalent to the percentage of on-time shipments. The NP-hardness of $1||\sum w_j U_j$ (i.e. the knapsack problem) has been established in a classic paper by Karp (1972) on computational complexity. Sahni (1976) presents a pseudo- polynomial time algorithm for this problem, and Gens and Levner (1981) gave fast approximate algorithm for the same. Potts and Van Wassenhove (1988) gave a very efficient algorithm for a linear programming relaxation of the knapsack problem.

Minimizing the number of tardy jobs, U_j, in practice, cannot be the only objective to measure how due-dates are being met. Some jobs may have to wait for an acceptably long time if the number of late jobs is minimized. If instead the sum of the tardiness is minimized, it is less likely that delay of any given job will be unacceptably long. The model $1 || \sum T_j$ has received an enormous amount of attention in the literature. For many years the computational complexity remained open until its NP-hardness was established by Potts and Van Wassenhove (1987). As $1 || \sum T_j$ in NP-hard in the ordinary sense, it allows for a pseudo-polynomial time algorithm based on dynamic programming. The NP-hardness of this has also been shown by Du and Leung (1990). The problem $1 || \sum w_j T_j$ is an important generalization of the above problem. Potts and Wassenhove (1985) used branch & bond algorithm for this problem. Dynamic programming & decomposition approaches were used for this problem by Potts & Wassenhove (1987, 1982). A dual algorithm was suggested by Fisher (1976). Simulated annealing appeared a viable approach to Potts and Wassenhove (1991).

More advanced single machine models (deterministic)

Since $1 \mid\mid \sum T_j$ is NP-hard, neither branch and bound nor dynamic programming can yield an optimal solution in polynomial time. Therefore, it may be of interest to have an algorithm that finds, in polynomial time, a solution that is close to optimal. An enormous amount of work has been done on Polynomial Time Approximation Schemes (PTAS). Lawler (1982) contributed significantly on this, and after a gap of fifteen years Chekuri et al. (1997) gave approximation schemes for average time scheduling. However, there are many interesting examples of PTAS for other scheduling as well e.g. Hochbaum & Shmoys (1987) gave dual approximate algorithm for the same Schuurman and Woeginger (1999) dealt with ten open problems concerning Polynomial Time Approximate Schemes.

In a generalization of the total tardiness problem, in addition to tardiness costs, there are also earliness costs also. These scheduling problems have non-regular objective functions like sum of the total earliness and total tardiness. The survey paper by Baker & Scudder (1990) focuses only on problem with earliness and tardiness penalties. The text by Baker (1995) has one chapter dedicated to problems with earliness and tardiness penalties. The text by Baker (1995) has one chapter dedicated to problems with earliness and tardiness penalties. Also in practice a scheduler is often concerned with more than one objective. For example, he may want to minimize inventory costs and meet due dates, so it would then be of interest to find a schedule that minimizes a combination of both. It is often the case where more than one schedule is optimal with respect to the given objective. A decision-maker may wish to consider a set of all schedules that are optimal with respect to a primary objective and then search within this particular set of schedules for the schedule, which is best with regard to a secondary objective. A fair amount of work has been done on single machine scheduling with multiple objectives.

Research have found out that single machine problem with two objectives allow for polynomial time solution (Emmons 1975, Van Wassenhove & Gelders 1980, Nelson et al. 1986). Posner (1985) considered the strongly NP-hard problem of minimizing the total weighted completion time with the jobs being subjected to deadlines. Chen & Bulfin (1993) presented a detailed overview of the state of the art for multi-objective single machine scheduling. They solved single machine-scheduling problem with two criteria; minimizing both maximum tardiness and number of tardy jobs. Gupta and Renu Ramnarayan [1996] proposed heuristic to find an approximate solution of the static machine scheduling problem with the objective of minimizing the maximum tardiness of any job subjected to the constraint that the total number of tardy jobs is minimum. Duffuaa et al. [1997] proposed an algorithm for one machine-scheduling problem with the objective of minimizing the mean tardiness subjected to maintain a prescribed number of tardy jobs.

There are situations where it is simply not acceptable to assume that the time required to set up facility for the next task is independent of the task was the immediate predecessor on the facility. Infact, the variation of setup time with sequence provides the dominant criterion for evaluating schedule. These situations are often found in process industries and are frequently associated with the problem of lot sizing. It has been reported in literature that sequence dependent set-up times are one of the most frequent additional complications in scheduling problem. Kim and Bobrowski [1994] conducted a simulation study to illustrate the impact of sequence dependent setup times on shop performance and concluded that setup time must be considered explicitly in any scheduling strategy when setup times are significant compared with processing time. For single machine scheduling problems with all $r_j = 0$ and no sequence dependent set up times, the makespan is independent of the sequence as equal to sum of processing times. When there are sequence dependent setup times, the make span does depend on the schedule. Also this has been shown as strongly NP-hard, and turns out to be equivalent of the travelling salesman problem. However, the NP-hardness of the problem in case of arbitrary setup times does not rule out the existence of efficient procedures when setup times have a special form. In practice, setup times often do have a special structure. Gilmore & Gommy (1964) presented a memorable paper dealing with the above problem. Bianco et al. (1988) considered various scheduling tasks with sequence dependent processing times. X.Sun et al. (1999) studied the scheduling of jobs on a single machine with release and due dates, sequence dependent setup times, and no preemption.

Single machine models (Stochastic)

Production environments in the real world are subjected to many sources of uncertainty or randomness. Sources of uncertainty with major impact include machine breakdowns and unexpected releases of high priority jobs. In the processing times, which are often not precisely known in advance, lies another source of uncertainty. Stochastic models, especially with exponential processing times, often contain more structure than their deterministic counterpart and may lead to results that, at first sight, seem surprising. Models that are NP-hard in a deterministic counterpart and may lead

to results that, at first sight, seem surprising. Models that are NP-hard in a deterministic setting often allow a simple priority policy to be optimal in a stochastic setting. A number of researchers have considered non-preemptive single machine scheduling problems with arbitrary processing time distributions [Rothkopf (1966), Crabill & Maxwell (1969) and Forst (1984)]. Hodgson (1977) considered simple machine sequencing with random processing times. For a number of stochastic problems, finding the optimal policy is equivalent to solving a deterministic scheduling problem. Usually, when such an equivalence relationship exists, the deterministic counterpart can be obtained by replacing all random variables with their means. The optimal schedule for the deterministic problem that minimizes the objective of the stochastic version in expectation.

Such problems lead to the stochastic version of the WSPT rule, which sequences the jobs in decreasing order of the ratio $w_j / E(X_j)$ or $\lambda_j w_j$. This rule is referred to either as the Weighted Shortest Expected Processing Time first (WSEPT) *rules or as the 'λ w'* rule which minimizes the expected sum of the weighted completion times in the class of non- preemptive static list policies as well as in the class of non-preemptive dynamic policies. Harrison (1975), Nain et al. (1989) worked with this rule and gave good results. Glazebrook (1984, 1987) evaluated the effects of machine breakdowns in stochastic scheduling problems and Pinedo & Rammouz (1988) also dealt with the same problems.

The problems with arbitrary distributions with preemptions reduce to a function called the Gittens index. This is due to Gittins and is explained by Gittins (1979). Many researchers have subsequently studied the use of Gittins indices in single machine stochastic scheduling problems and other application like Whittle (1981), Glazebrook (1981) and Katehakis and Veinott (1987). The proof of optimality of Gittins indexes was presented by Weber (1992). In a number of cases the distributions of the random variables did not matter at all; only their expectations played a role. Brown & Solomon (1973) considered processing time distributions that are likelihood ratio ordered and subject to deterioration. Also Browne and Yechciali (1990) dealt with the same on a single processor. Derman et al. (1978) and Pinedo (1983a) treated upon single machine scheduling with exponential processing time distribution. Sarin et al. (1990) dealt with due date related objectives with processing time distributions that were not exponential.

Single machine models with release dates (Stochastic)

In many stochastic environments, all the jobs are often not available at time zero. The jobs come in at different times and randomly. So single machine model occurs with the jobs having random processing times and random release dates. It is somewhat similar to the models considered in group theory. An environment with release dates is somewhat similar to the models considered in theory. In a priority theme, a server (or machine) has to process customers (or jobs) from different classes and each class has its own priority level (or weight). The most general model under this category is that when there are arbitrary releases and arbitrary processing times without preemption, which is a stochastic counterpart of $1 \mid r_j \mid \sum w_j C_j$.. The other model considered is with arbitrary releases and exponential processing times with preemptions, which is a stochastic counterpart of the deterministic model $1 \mid r_j, prmp. \sum w_j C_j$.. (known to be strongly NP-hard). Pinedo (1983b) has proved the optimality of WSEPT when processing times are exponentially distributed and release times are arbitrary with preemptions allowed. Wolff (1989) has mentioned various similarities between stochastic scheduling with random release dates and priority queues in his book. Cobham (1954) proved the optimality of WSEPT when the jobs are released according to Poisson processes, the processing times are arbitrarily distributed, and no preemptions are allowed.

Conclusions

Single machine models are considered to be the most important models as all the problems with complicated environments are often decomposed into problems that deal with single machines. The following conclusions can be drawn from the above review and discussions:

- The models having regular objective functions are relatively easy to solve. Some are solvable via simple priority rules (e.g., WSPT, EDD), but most of the models are solvable either in polynomial or pseudo-polynomial time. The models that are solvable in polynomial time are usually dealt with through dynamic programming. Only strong NP-hard problem can be solved for obtaining optimal solutions using two approaches – namely branch and bound and dynamic programming.
- Over the last decade, polynomial time approach schemes (PTAS) have received an enormous amount of attention. Most of this attention has focused on NP-hard problems that lie close to the boundaries that separate NP-hard problems from polynomial time problem. Problems with earliness and tardiness penalties have recently received a significant amount of attention. Also because of importance of multiple objectives in

practice, a considerable amount of research has been done on problem with multiple objectives. Of course, these problems are harder than the problems with just a single objective. So most problems with two objectives are NP-hard. These types of problems may attract in the near future the attention of investigators who specialize in PTAS. Also the makespan minimization problem when the jobs are subjected to sequence dependent setup times turns out to be equivalent to the Traveling Salesman Problem.

- When jobs having arbitrary processing time distributions and released with preemption allowed are considered at the same time, then the Gittins index policy is optimal. It turns out that when jobs are released according a poisson process, an index is then not as easy to characterize as the Gittins index. Stochastic models, especially with exponential processing times often contain more structure than their deterministic counterparts and may lead to results that, at first sight, seem surprising. Models that are NP-hard in a deterministic setting often allow a simple priority policy to be optimal in a stochastic setting.

References

Baker K.R. (1995), "Elements of Sequencing and Scheduling", K. Baker, Amos Tuck School of Business Administration, Dartmouth College, Hanover, New Hampshire.

Baker K.R. & Scudder G.D. (1990), "Sequencing with Earliness and Tardiness Penalties: A Review", Operations Research, Vol. 38, pp. 22-36.

Bianco L., Ricciadelli S., Rinaldi G. & Sassano A. (1988), "Scheduling Tasks with Sequence-Dependent Processing Times", Naval Research Logistics Quarterly, Vol. 35, pp. 177-184.

Brown M. & Solomon H. (1973), "Optimal Issuing Policies under stochastic Field Lives", Journal of Applied Probability, Vol. 10, pp. 495-498.

Browne M. & Yechiali U. (1990), "Scheduling Deteriorating Jobs on a Single Processor", Operations Research, Vol. 38, pp. 495-498.

Chekuri C., Motwani R., Natarajan B. & C. Stein (1997), "Approximation Techniques for Average Completion Time Scheduling", in Proceedings of the Annual ACM-SIAM Symposium on Discrete Algorithms (SODA), pp. 609-617.

Chen C.L. & Bulfin R.L. (1993), "Complexity of Single Machine, Multi-Criteria Scheduling Problems", European Journal of Operational Research, Vol. 70, pp. 115-275.

Cobham A. (1954), "Priority Assignment in Waiting Line Problems", Operations Research, Vol. 2, pp. 70-76.

Crabill T.B. & Maxwell W.L. (1969), "Single Machine Sequencing with Random Processing Times and Random due-dates", Naval Research Logistics Quarterly, Vol. 16, pp. 549-554.

Derman C., Lieberman G., & Ross S.M. (1978), "A Renewal Decision Problem", Management Science, Vol. 24, pp. 554-561.

Du J. & Leung J.Y.T. (1990), "Minimizing Total Tardiness on One Machine is NP-Hard", Mathematics of Operations Research, Vol. 15, pp. 483-495.

Duffuaa S.O., Raouf A., Ben-Daya M. & Makki M. (1997), "One-Machine Scheduling to minimize mean tardiness with minimum number tardy", Production Planning and Control, Vol. 8, pp. 226-230.

Emmons H. (1975), "A Note on a Scheduling Problem with Dual Criteria", Naval Research Logistics Quarterly, Vol. 22, pp. 615-616.

Fisher M.L. (1976), "A Dual Algorithm for the One-Machine Scheduling Problem", Mathematical Programming, Vol. 11, pp. 229-251.

Forst F.G. (1984), "A Review of the Static Stochastic Job Sequencing Literature", Opsearch, Vol. 21, pp. 127-144.

Gens G.V. & Levner E.V. (1981), "Fast Approximation Algorithm for Job Sequencing with Deadlines", Discrete Applied Mathematics, Vol. 3, pp. 313-318.

Gilmore P.C. & Gomory R.E. (1964), "Sequencing in a One-State Variable Machine: A Solvable Case of the Travelling Salesman Problem", Operations Research, Vol. 12, pp. 655-679.

Gittins J.C. (1979), "Bandit Processes and Dynamic Allocation Indices", Journal of the Royal Statistical Society Series B, Vol. 14, pp. 148-177.

Glazebrook K.D. (1981b), "On Non-preemptive Strategies in Stochastic Scheduling", Naval Research Logistics Quarterly, Vol. 28, pp. 289-300.

Glazebrook K.D. (1984), "Scheduling Stochastic Jobs on a Single Machine Subject to Breakdown", Naval Research Logistics Quarterly, Vol. 31, pp. 251-264.

Glazebrook K.D. (1987), "Evaluating the Effects of Machine Breakdowns in Stochastic Scheduling Problems", Naval Research Logistic Quarterly, Vol. 31, pp. 251-264.

Gupta, J.N.D. & Ramnarayanan R. (1996), "Single Facility scheduling with Dual criteria: Minimizing maximum tardiness subject to minimum number of tardy jobs", Production Planning and Control, Vol. 7, pp. 192-196.

Harrison J.M. (1975b), "Dynamic Scheduling of a Multiclass Queue: Discount Optimality", Vol. 23, pp. 270-282.

Hochbaum D.S. & Shmoys D.B. (1987), "Using Dual Approximation Algorithms for Scheduling Problems: Theoretical and Practical Results", Journal of the ACM, Vol. 34, pp. 144-162.

Hodgson T.J. (1977), "A Note on Single Machine Sequencing with Random Processing Times", Management Science, Vol. 23, pp. 1144-1146.

Jackson J.R. (1955), "Scheduling a Production Line to Minimize Maximum Tardiness", Research Report 43, Management Science Research Project, University of California, Los Angeles.

Karp R.M. (1972), "Reducibility among Combinational Problems", in Complexity of Computer Computations, R.E. Miller and J.W. Thatcher (eds.), Plenium Press, New York.

Katehakis M.N. & Veinott A.F. (1987), "The Multi-Armed Bandit Problem: Decomposition and Computation", Mathematics of Operations Research, Vol. 12, pp. 262-268.

Kim S.E. & Bobrowski P.M. (1994), "Impact of sequence dependent setup time on job shop scheduling performance", International Journal of Production Research, Vol. 32, pp. 1503-1520.

Lawler E.L. (1973), "Optimal Sequencing of a Single Machine subject to Precedence Constraints", Management Science, Vol. 19, pp. 544-546.

Lawler E.L. (1978), "Sequencing Jobs to Minimize Total Weighted Completion Time Subject to Precedence Constraints", Annals of Discrete Mathematics, Vol. 1, pp. 75-90.

Lenstra J.K., Rinnooy Kan A.H.G. & Brucker P. (1977), "Complexity of machine scheduling problems", Annals of Discrete Mathematics, Vol. 1, pp. 343-362.

McMahon G.B. & Florian M. (1975), "On Scheduling with Ready Times and Due Dates to Minimize Maximum Lateness", Operations Research, Vol. 23, pp. 475-482.

Monma C.L. and Sidney J.B. (1979), "Optimal Sequencing via Modular Decomposition: Characterizations of Sequencing Functions", Mathematics of Operation Research, Vol. 12, pp. 22- 31.

Nain P., Tsoucas P., and Walrand J. (1989), "Interchange Arguments in Stochastic Scheduling" Journal of Applied Probability, Vol. 27, pp. 815-826.

Nelson R.T., Sarin R.K. and Daniels R.L. (1986), 'Scheduling with Multiple Performance Measures: The One Machine Case", Management Science, Vol. 32, pp. 464-479.

Pinedo M. (1983), "Stochastic Scheduling with Release Dates and Due Dates", Operations Research, Vol. 31, pp. 559-572.

Pinedo M. & Rammouz E. (1988), "A Note on Stochastic Scheduling on a Single Machine Subject to Breakdown and Repair", Probability in the Engineering and Informational Sciences, Vol. 2, pp. 41-49.

Posner M.E. (1985), "Minimizing Weighted Completion Times with Deadlines", Operations Research, Vol. 33, pp. 562-574.

Potts C.N. (1980), "Analysis of a Heuristic for One Machine Sequencing with Release Dates and Delivery Times", Operations Research, Vol. 28, pp. 1436-1441.

Potts C.N. & Van Wassenhove L.N. (1987), "Dynamic Programming and Decomposition Approaches for the Single Machine Total Tardiness Problem", European Journal of Operational Research, Vol. 32, pp. 405-414.

Potts C.N. & Van Wassenhove L.N. (1988), "Algorithms for Scheduling a Single Machine to Minimize the Weighted Number of Late Jobs", Management Science, Vol. 34, pp. 843-858.

Potts C.N. & Van Wassenhove L.N. (1991), "Single Machine Tardiness Sequencing Heuristics", IIE Transactions, Vol. 23, pp. 346-353.

Rothkopf M.H. (1966a), "Scheduling independent Tasks on Parallel Processors", Management Science, Vol. 12, pp. 437-447.

Sahni S. (1976), "Algorithms for Scheduling Independent Tasks", Journal of the Association of Computing Machinery, Vol. 23, pp. 116-127.

Sarin S.C., Steiner G. & Erel E. (1990), "Sequencing Jobs on a Single Machine with a Common Due Date and Stochastic Processing Times", European Journal of Operational Research, Vol. 51, pp. 188-198.

Schuurman P. & Woeginger G. (1999), "Polynomial Time Approximation Algorithms for Machine Scheduling: Ten Open Problems", Journal of Scheduling, Vol. 2, pp. 203-214.

Smith W.E. (1956), "Various Optimizers for Single Stage Production", Naval Research Logistics Quarterly, Vol. 3, pp. 59-66.

Sun Xiaoqing, Noble J.E. & Klien C.M. (1999), "Single Machine Scheduling with sequence dependent setup to minimize total weighted squared Tardiness", IIE Transactions, Vol. 31, pp. 113- 124.

Van Wassenhove L.N. and F. Gelders (1980), "Solving a Bicriterion Scheduling Problem", European Journal of Operational Research, Vol. 4, pp. 42-48.

Weber R.R. (1992), "On the Gittins Index for Multi-Armed Bandits", Annals of Applied Probability, Vol. 2, pp. 1024-1033.

Whittle P. (1981), "Arm Acquiring Bandits", Annals of Probability, Vol. 9, pp. 284-292.

Wolff R.W. (1989), "Stochastic Modeling and the Theory of Queues", Prentice Hall, Englewood Cliffs, New Jersey.

□

A particular shot or way of moving the ball can be a player's personal signature, but efficiency of performance is what wins the game for the team.

– Pat Riley

Feature

Decision-making Model for Economical Wastepaper Collection

Rupesh Kumar Pati, Prem Vrat & Pradeep Kumar

Reverse logistics refers to all the logistic activities to collect and process used products and/or parts in order to ensure eco-friendly recovery. This paper proposes a decision-making model which acts as a framework for economical collection of wastepaper from the customer by the dealer. Use of this model also improves the quality of the wastepaper being recycled.

Rupesh Kumar Pati is Research Scholar, Prem Vrat is Director and Pradeep Kumar is Professor at IIT, Roorkee.

Conservation of earth's resources is crucial for a sustainable future for humanity. Many waste materials generated from human activities may be recycled and thus, become a resource for industrial production or energy generation. Recyclable waste was previously discarded, as it was considered useless. But, in recent years there has been a surge of interest in the waste recovery and recycling in both the developing and the developed world. The goal of conserving and protecting natural resources has shifted the central concern of waste management from disposal towards waste prevention and recycling.

Factors such as political pressure and public opposition to disposal sites, economic pressure of the high cost of waste disposal due to land shortage (increasing the cost of landfills) and stringent regulatory standards of waste disposal are forcing many industrialized countries to opt for recycling (Cointreau and de Kadt, 1991; Hooper and Nielsen, 1991). This trend towards increased material and energy efficiencies, and increased recycling are similar across various industries.

The pulp and paper sector presents one of the energy incentive and highly polluting sectors within the Indian economy and is therefore of particular interest in the context of both local and global environmental discussions. Increase in productivity through the adoption of more efficient and cleaner technologies in the manufacturing sector will be the most effective in merging economic, environmental and social development objectives. Paper recycling is one such technique.

Indian paper industry

Paper industry is one of the key industrial sectors in the Indian economy. The pulp and paper industry in India has a tremendous growth potential, which is currently estimated at 8 per cent per annum. The per capita

paper consumption figure in India was 3.6 kg (1995), which is very low as compared to the world average of 45.6 kg (1995). The consumption levels are estimated to reach 6.0 kg in 2005/06 (IPMA, 1996). Although per capita consumption of paper in India is very low compared to other countries, the paper industry holds a considerable share in manufacturing/production sector. Today, more than 380 small and big paper mills produce a variety of different paper, paperboard as well as newsprint products. Cultural paper constitutes the biggest share in production with 41% (in 1991), followed by Kraft paper with 27% share, paperboard with 17%, newsprint with 12% and specialty paper at 3% (Sharma et al., 1998).

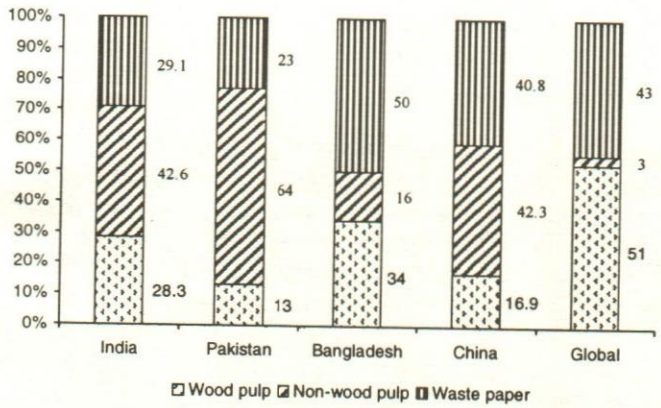


Fig. 1. Structure comparing Global, China and Indian subcontinent Paper Industry

Demand for the paper and the paper product has continuously been increasing over time. Consumption of paper and paperboard equaled 1.2 million tonnes in 1980-81 and increased to 2.6 million tonnes in 1994-95. Imports of paper and paperboard accounted for about 7% of consumption in 1980-81. This figure increased to over 10% in 1994-95. On an average, about 0.2 million tonnes of newsprint (about 40% of consumption) had to be imported in the last few years (Schumacher and Sathaye, 1999). It has been projected, that with the existing resources, there would be shortfall of 5.1 million tonnes between the demand and supply by 2015-16 (Sharda et al., 2000). Paper recycling is an effective way to fill this gap as well as benefit the ecosystem.

The comparative analysis of the furnish structure in global, China and Indian subcontinent's paper industry is depicted in figure 1 (Panwar et al., 2001). It can clearly be seen that the percentage of wastepaper utilized in India for the production process (29.1%) is considerably less compared to most of the countries accounted for. The global recovered paper consumption grew from 49.9 million tonnes between 1990 and 1998, reaching 135 million tonnes in 1998. In 2005, it is forecast that 174 million tonnes of recovered paper will be used globally. From 1998-2005, rate of increase of recovered paper is 3.6% annually (Gnanasekaran et al., 2001).

Paper is a major component of the overall municipal solid waste stream. The ill-effect of the burning and land filling of wastepaper on the eco-system in India has been studied previously and is illustrated in table 1 (Beukering et al., 1996). Thus, wastepaper recycling is seen as one important waste management strategy to prevent the ecosystem from degradation. Recycling of the wastepaper reduces the need for the disposal capacity, which in turns leads to lower emissions from landfills. The present scenario of the Indian paper industry leads to:-

- Shortage of forest based fibrous raw material,
- Problems in the processing of the agro residues,
- Increasing environmental pressure and
- Stringent discharge norms and high cost of inputs for the treatment of the effluent.

Table 1: Effect of burning and land filling of waste paper on the eco-system

Output	Burning of Waste Paper (1000 kg) Quantity (kg)	Landfill of Waste Paper (1000 kg) Quantity (kg)
Solid waste	55.87609	55.87609
CO_2	939.624	142.35658
CO	1.39999	0.00062645
VOC	0.299334	0.299334
NO_x	1.500028	0.00156613
SO_2	1.300009	1.300009
CH_4	–	51.767331
HC	–	0.00031323
Particles	–	0.0012592
Organic matter	–	751.22513

The major advantages associated with the increasing use of recycled fibre by the paper industry are its sustained availability and eco-friendly uses, low cost, high fibre yield, less capital investment and lower water, energy and chemical consumption compared to the integrated mills based on the wood or agro residues.

The mills based on wastepaper prefer to use imported wastepaper because of its better quality in terms of fibre strength and also due to inadequate domestic supply owing to the unorganized collection of waste

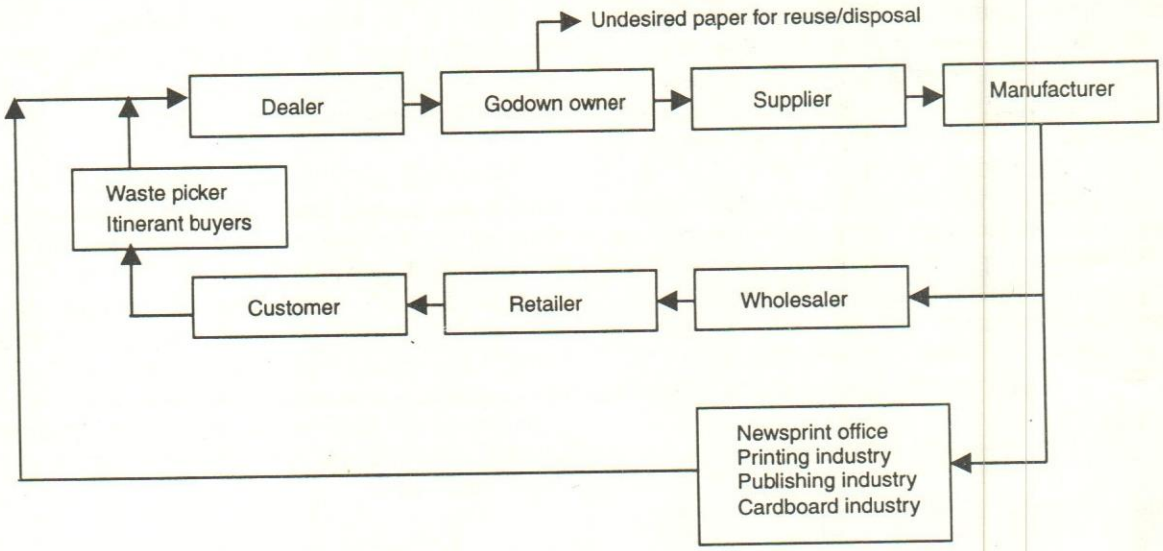


Fig. 2. Participants/entities of paper recycling system

paper within the country. The yield from each tonne of imported waste paper can be as high as 0.9 tonne, which is considerably higher compared to the yield for agro-pulp (0.4 tonne) and wood-pulp (0.5 tonne) based paper. Also, using wastepaper consumes only 40% of the energy required for the process based on other raw materials (Gupta et al., 1998).

The wastepaper percentage is going to be much higher in future as paper consumption increases due to increase in population and literacy rate. However, to keep pace with demand, one would need to recover and recycle paper considering the likely shortage of paper. But, the recovered paper collection and sorting are highly labour-intensive processes. The characteristics of the collection system are decided by the population density, number of households covered by the programme and the waste stream characteristics (Jaher, 1995). There are possibilities for efficient collections by creative route planning and vehicle development. Hence this paper proposes a framework of a decision-making model for an economic collection of the wastepaper from the initial source i.e. the vendor customer, by planning the route creatively for vehicular movement. This model can further be extended for collection of wastepaper between other pairs of entities (stages) in the reverse supply chain.

Indian paper recycling system

The Indian paper recycling system consists of five entities or participants in the recycle collection chain to carry out reverse logistics activities involving collection of wastepaper/used paper from the customer/industries to the manufacturer. The members of this reverse supply chain include the dealer, who collects the unsegregated wastepaper from the customers/industrial houses through the waste pickers and itinerant buyers. The supplier finally sends the segregated recyclable paper to the manufacturer for production of new paper. The supplier collects the desired segregated waste from the godown owner stage where segregation is done.

The forward supply chain completes the entire paper recycling system and takes care of the logistic activities concerning the movement of finished paper after production till it reaches the desired final customer. The members of the forward supply chain are the wholesaler, retailer and the final customer (with industrial houses as an exception, as they may fulfill their need directly from the manufacturer). The representation of the paper recycling system can be pictorially represented as shown in figure 2.

Majority of the waste pickers are unskilled migrants, who roam the street and dumpsites to collect any type of material that they can sell to the dealer. The itinerant buyers are also mobile but instead of picking waste from the bins and dumpsites, they go from door to door by bicycle to buy the waste from households or shops. The materials collected by itinerant buyers have not been mixed with disposable waste; the quality is much higher than the wastepaper gathered by the waste pickers (Beukering et al., 1996b). In order to improve the quality of recyclable paper and reduce the collection cost, the dealer should devise an effective collection strategy. In this strategy the dealer should collect wastepaper directly from the customer, eliminating the waste picker/itinerant buyer stage. The elimination of the intermediate stage also reduces the travel time for the collected wastepaper to move from the source to the recycling unit. When the customer is involved directly with the dealer, they can be

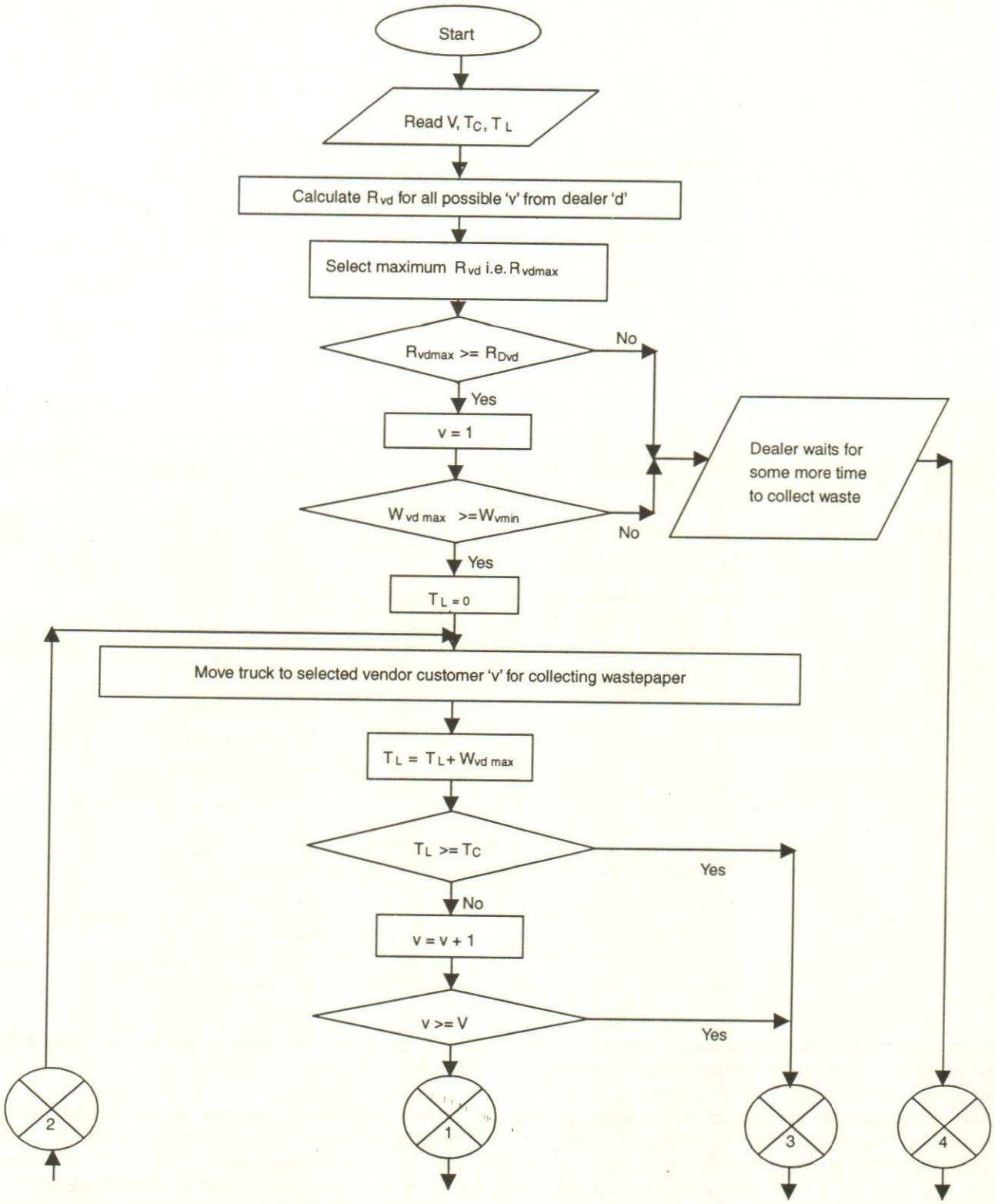


Fig. 3. Wastepaper collection decision-making model (contd.)

known as vendor customer i.e. VC (as they are the final customer of finished paper as well as the initial vendor for the recyclable paper).

Wastepaper collection decision-making model

For the purpose of collecting the wastepaper, the

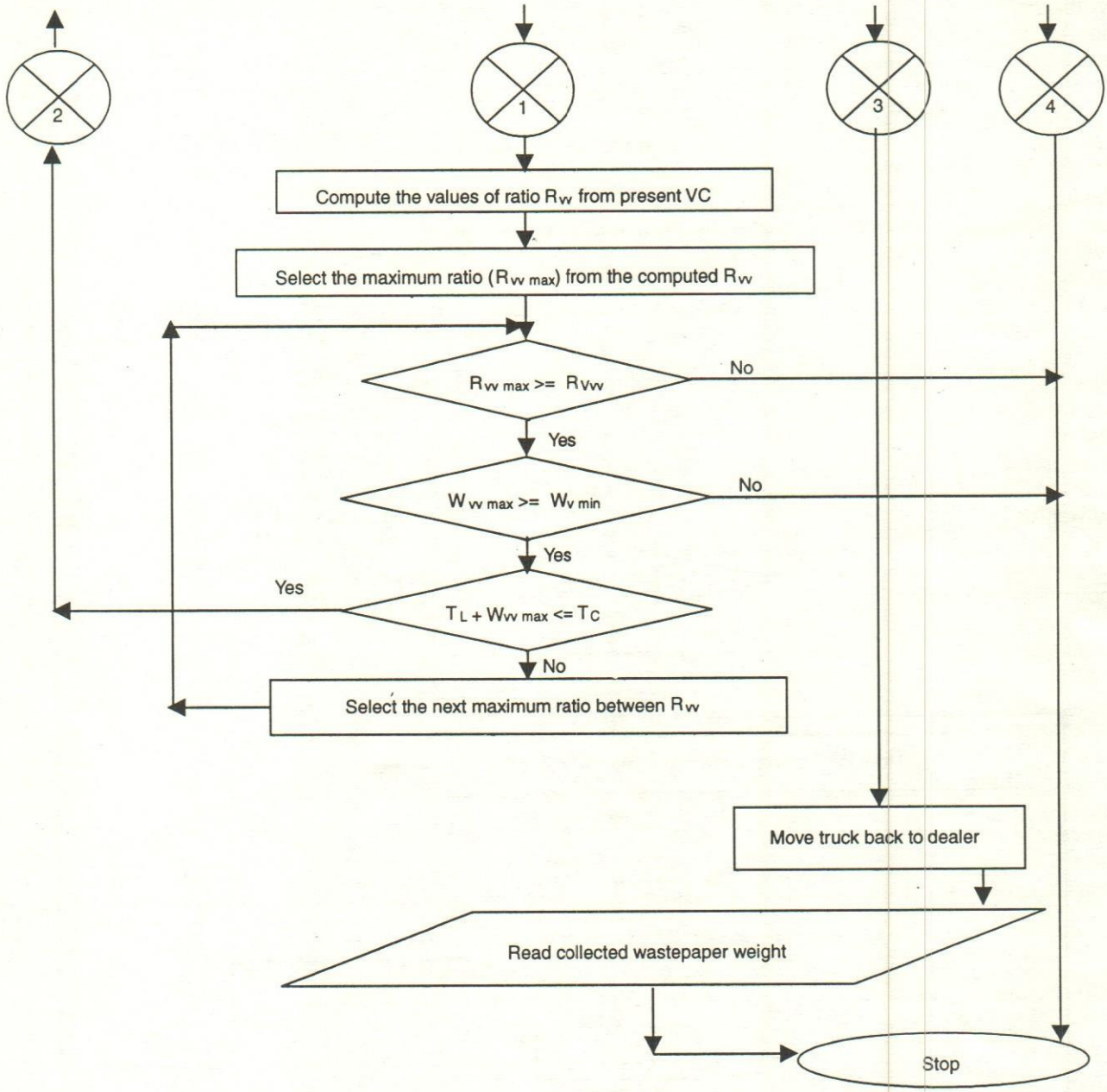


Fig. 3. Wastepaper collection decision-making model (contd. from above)

ultimate consumer/vendor customer can be divided into three categories i.e. single-family house, residential apartments and the industrial/institutional sectors. The quantity of wastepaper generated in a specific period increases as one moves from single-family houses to the industry/institutes. For the purpose of efficient collection, the dealer should facilitate a collection point in some particular groups of single-family houses, apartments and industry/ institute. These categories and collection points should be formed on the basis of the amount of waste generated by these categories in a specified period of time. These collection points can be termed as vendor customer collection points or simply vendor customers (VC).

The proposed decision-making model for an economic collection of wastepaper from the initial source i.e. vendor customer by the dealer is shown in figure 3. The purpose of the proposed model is to guide the dealer to make and implement decision on the wastepaper collection route from the set available vendor customers. The model runs on a pair of assumption. At first, the distance between the various entities and sub-entities needs to be known. Second-

ly, the data relating to the average wastepaper collection at the vendor customer during a particular period are required before the decision model is utilized.

The model depicts several key steps in the form of flowchart to help the dealer in the collection through proper vehicular movement. This model also guides the dealer in proper manpower planning for the collection purpose. The decision for cost efficient and effective vehicular collection of wastepaper depends on the decision taken on two separate stages combined together.

The first stage of the model determines time and direction of the movement of the collecting vehicle (i.e. say truck) from a predetermined dealer. The parameters that affect the decision-making in the first stage are ratios of weight of wastepaper to be collected from the vendor customer 'v' by the dealer 'd' to the distance moved between them (R_{vd}); weight of wastepaper ($W_{v\ d\ max}$) at the vendor customer 'v' for maximum R_{vd}. The second stage determines the time and direction of vehicular movement from the vendor customer (VC) selected in the previous stage. The second stage includes the decision on whether the collecting vehicle should move to another vendor customer or return back. The decision of the second stage depends on capacity of the truck (T_C), present load carried by vehicle (T_L), ratio of the weight of wastepaper in uncovered vendor customer to traversing distance from present vendor customer (R_{vv}) and finally, weight of wastepaper ($W_{v\ v\ max}$) at the vendor customer 'v' with maximum R_{vv}. The total number of vendor customers (V) available for collection of the wastepaper also affects the second stage decision.

The other notations used in figure 3 are given below:

$R_{vd\ max}$ = Maximum of all the R_{vd} Values,

R_{Dvd} = Minimum desired R_{vdmax} for truck to be moved from dealer 'd' to VC 'v',

$W_{v\ min}$ = Desired minimum weight of wastepaper to be collected from vendor customer.

$R_{vv\ max}$ = Maximum of all the R_{vv} computed for a particular vendor customer as reference,

R_{Vvv} = Minimum desired ratios of R_{vv} for the truck to travel/move between two VC's to collect wastepaper.

Conclusion

The new concept of reverse logistics is slowly but steadily entering into all the prime industrial sectors of Indian economy. This concept goes a long way to improving the energy, raw material and thus the total productivity of any firm/industry. For the paper industry to sustain itself in the fiercely competitive global market, growing wastepaper stock must be utilized to displace some of the virgin raw material, i.e. wood pulp used in the production process. The reverse logistics process used in the paper industry also helps in improving the eco-system, which is constantly being deprived of the precious forest cover. But the major problem in the recycling of paper is the difficulty and uneconomical collection of the used paper from the vendor customers. The proposed decision model provides the dealer of the recycled paper industry with a framework for economic collection of wastepaper from the specified set of vendor customer collection points. Use of this model also ensures an improved quality of wastepaper available for recycling, as it is not mixed with other waste in the dumpsites. All this has direct impact on the improved productivity in the paper recycling. This model can further be extended to other layers of the reverse supply chain e.g. collection of wastepaper by godown owner from the specified set of dealers.

References

Beukering, P. van, Schoon, E. and Mani, A. (1996), "The informal sector and waste paper recovery in Bombay", CREED Working Paper series no. 5. International Institute for Environment and Development, Amsterdam.

Cointreau, Sandra J. and de Kant, Maorten. (1991), "Living with garbage: cities learn to recycle", Development Forum, January-February, pp. 12-13.

Gnanasekaran, A., Raman, G.V., and Venkoba Rao, G. (2001),"Suitability of Secondary Fibre - White Blank News on Newsprint Manufacturer - A Case Study", IPPTA Journal Vol. 13, No.3, pp. 1-6.

Gupta, S., Mohan, K., Prasad, R., Gupta, S. and Kansal, A. (1998), "Solid waste management in India: options and opportunities", Resource, Conservation and Recycling, Vol. 24, pp. 137-154.

Hooper, J.R., and Neilsen, J.N. (1991), "Recycling is altruistic behavior: normative and behavioral strategies to expand participation in a community recycling program", Environment and Behavior, Vol. 23, No.2, March, pp. 195-210.

Jaher, M. (1995), "Logistics system for recycling-efficient collection of household waste. Goteborg, Sweden", Department of Transportation and Logistics, Chalmers University of Technology.

Panwar, S., Endlay, N., Pandey, A., and Mathur, R.M. (2001). "Biomethanation Technology – An option for treatment of effluent generated and recycled fibre based mills", IPPTA Journal Vol. 13, No.3, pp. 43-59.

Schumacher, K. and Sathaye, J. (1999), "India's Pulp and Paper Industry: Productivity and Energy Efficiency", Energy analysis program, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, Berkeley.

Sharda A.K., Mukherjee S. and Ratho B.P. (2000), "Cellulosic raw materials scenario in future" IPPTA.J, Vol. 12, No.1, 17-23, March.

Sharma, Vinod K., Ramaswamy, K.V., Vaidya, R.R., Hadker, N. and P. van Beukering, (1998), "The Indian Paper Industry", in: Beukering, Pieter van, Vinod K. □

Feature

Application of Taguchi's Robust Design Approach for Hospital Services in India

Roma Mitra Debnath & Ravi Shankar

Systematic management of issues related to public health is an important concern for a developing nation like India. Customers' concerns need to be reflected in the operating model of this sector. Taguchi method of parameter design has been applied in this research to decide the optimum standard for Indian hospitals. The result brings out important factors for the effectiveness of Indian health services, including timely consultation, availability of doctors, post-operative care, patients' awareness about the side effects of the treatment, etc.

Roma Mitra Debnath is a lecturer at the Fore School of Management, New Delhi, and Ravi Shankar is a faculty at IIT, New Delhi.

Globally the healthcare sector is becoming a major concern as nations are constantly struggling with issues like minimization of costs and maximization of value in the health services.

Today, due to insufficient budgetary support to the Indian health sector, it is difficult to provide even basic health facilities, thus leading to a wide disparity in catering to the basic needs of people across the country. In terms of public spending on health, India ranks 171st out of 175 countries (Human Development Report, 2004). To overcome this problem, several state governments are trying to involve private sectors in public health care activities and motivating them to work jointly. This is done with a hope that private sector involvement would bring investment into the health sector and would provide better health services to the people. There is always a question mark on the role of the private sector in health services due to its apathy towards the poor population of the nation.

In healthcare a focus on meeting patients' needs is a major challenge in the service sector. In India the service quality differs from government to private healthcare providers. Those who can afford to bear the expenses go to private healthcare institutes and the rest are dependent on facilities rendered by government managed healthcare institutions.

The objective of this research is to analyse the quality services in the healthcare system available in India. For this Taguchi's robust design is used to set-up an optimum condition for the quality services from the patient's point of view.

Literature Review

Many researchers have established a need to consider the customer point of view in deciding priority in service sector. Martin et al. (2004) mentioned the role of

patients as a decision-maker in a priority setting. The patients' representative focuses on the needs of patients and the impact of particular treatments from the point of view of prospective patients. It actually represents the contribution to the understanding of patients' needs and the impact of various attitudes on patients. As Davis (2004) rightly mentioned that a full-blown model from stakeholders' point of view should be developed which could be very instructive. "When setting priorities in the health sector, interventions that 'add years to life' must be compared with interventions that 'add life to years'...." – as said by Arnesen and Trommald (2004).

This paper also discusses that there is a wide agreement that the patient's perspective is often, but not always recommended. The authors perform cost utility analysis for setting the priorities in the healthcare system. They weighed the quality of life on a scale from 0.00 to 1.00 but don't talk about the optimum condition required for the health care system. Staat et al. (2000) discussed a method called Data Envelopment Analysis (DEA) for the benchmarking of the German hospitals. DEA is particularly suited for the analysis of technical efficiency of public sector service provision as no price information for inputs and outputs is needed to determine the degree of technical (in)efficiency in a multiple-input multiple-output setting. The disadvantage of this method is that it does not give us any information on how to set an optimum standard for the hospitals.

Taguchi's approach has been used in many areas to set the optimal level for given factors. Holscomb (1994) mentioned in her research paper how to develop a comprehensive method for designing, assessing and improving customer service offerings, from both quality and cost perspective by using Taguchi's methods. Different Orthogonal arrays are considered for control and noise factors and then the analysis is carried out. Taguchi method is also used in real estate industry. Kethley et al. (2002) used Taguchi's loss function to identify the properties that most closely matches the buyer's preferences, choice criteria and needs, the utility of the buyer/broker relationship, as well as level of customer service and satisfaction should be improved. Palanikumar and Karunamoorthy (2003) used Taguchi's approach to a composite machining process to optimise FRP composite.

Taguchi (1959, 1987) developed a new method of process optimisation, which is known as Taguchi Methods. Roy (1990) mentioned that Taguchi method offers two new powerful elements. First, it is a disciplined way of developing a product or investigating complex problems. Second, it provides a mean to cost effectively investigate the available alternatives. Although this method is built upon well-developed concepts of optimisation through the design of experiments, his philosophy regarding the value of quality and the procedure for carrying out experiments are new. The power and popularity of the method lies in the discipline rather than technique itself.

In the 1960s, Genichi Taguchi pointed out the important implications of S/N ratio for the quality level of measuring instruments and measuring methods. The S/N ratio makes it possible to express the quality of a certain design quantitatively. It makes it possible to quantify the characteristics of actual products, which had been evaluated subjectively but not quantitatively and this contributes to efficient quality improvement.

Taguchi has developed over 70 distinct S/N ratios. There are four S/N ratios, which are used in most of the times, they are (equations 1,2,3,4)

$$\text{S/N smaller the better} = -10 \log [S^2 + \bar{y}^2] \quad ...(1)$$

$$\text{S/N larger the better} = -10 \log [1/n \sum 1/y_i^2] \quad ...(2)$$

$$\text{S/N nominal the best} = -10 \log s^2 / \bar{y}^2 \quad ...(3)$$

Where S^2 is the sample variance and $\bar{y}$ is the mean

$$\text{S/N operating window type} = -10 \log [\sum y_i^2/n] - 10 \log [1/\sum 1/y'^2_i] \quad ...(4)$$

Most of the benefits of improved design quality come after the product is put in use. The reduced variation, a characteristic that is designed through the optimum combination of the factors, yields consistent performance of the product. This means that the more the products will perform as designed, there will be happier customers, and therefore, less warranty costs, and increased sales.

Area of Research

This paper tries to find out the guiding principles for the future care delivery model from a customers' perspective. The major issues are the challenges existing in health care systems and how these challenges can be effectively met.

As Lewis and Booms (1983) defines "Service Quality is a measure of how well the service level delivered matches customer expectations. Delivering quality service means conforming to customer expectations on a consistent basis." Beach and Burns (1995) developed a model based on customers' satisfaction and dissatisfaction, which was different from the model given by

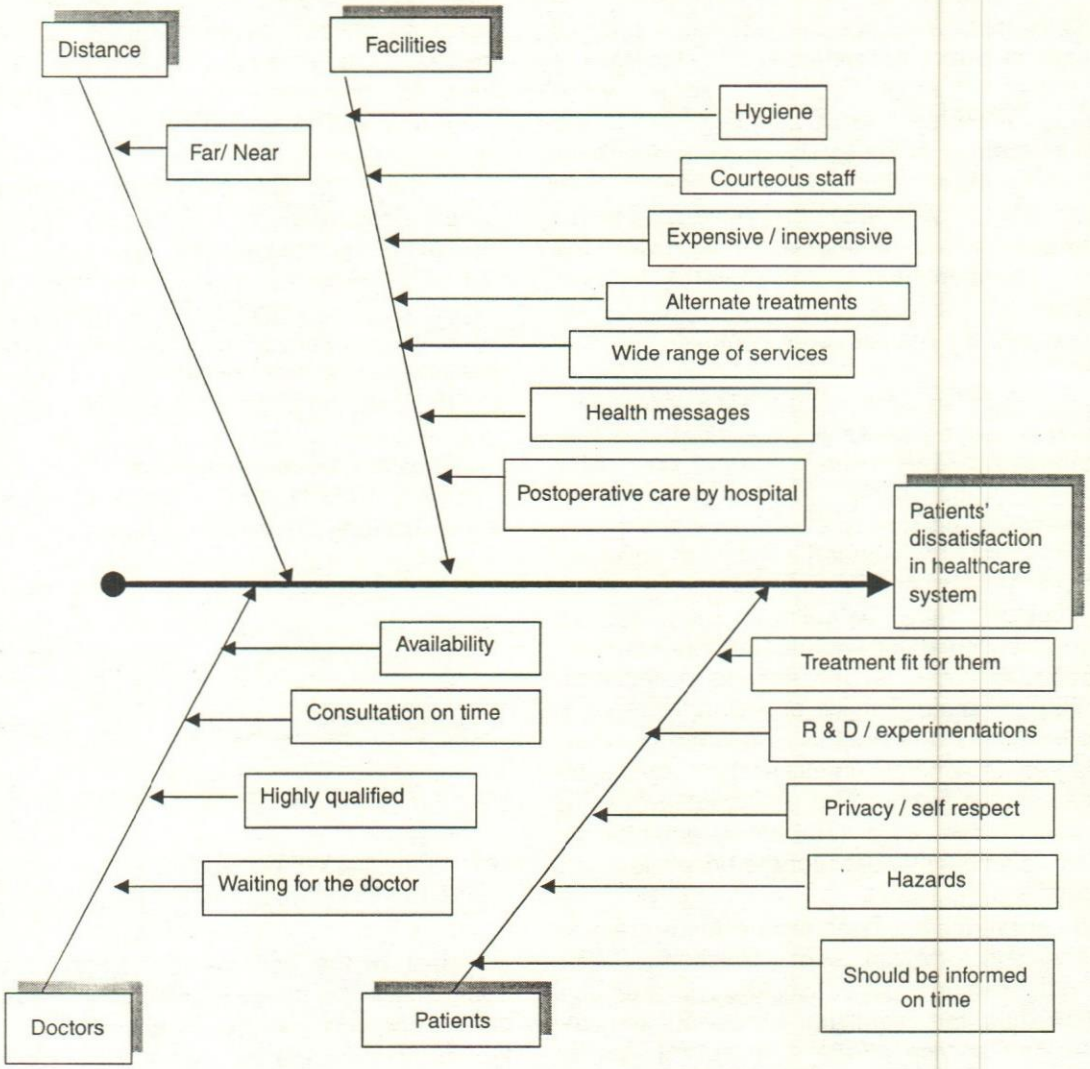


Fig. 1. Ishikawa Diagram

Parasuraman et al. (1985). Beach and Burns (1995a) discusses about a gap analysis which is viewed as a function of the difference between what the worker expects from a job and what he/she experiences. A similar approach has also been adopted in this research.

The Experimental design

In the initial discussion with the important stakeholders i.e. patients, the following list of sequential steps were considered essential in order to build an optimisation model for the hospital, which is a non-zero tolerance for mistakes. These steps are:

- define the problem and objective in quantitative terms,
- conduct a brainstorming sessions to identify important factors and their levels,
- select the appropriate Orthogonal Array, which can estimate the impact of important factors,
- prepare a questionnaire and collect the appropriate data from the experience and observation of the patients,
- conduct ANOVA and other Taguchi-related analysis,
- identify the significant factors with their corresponding levels,
- find the optimal combination of the important factors for the optimisation of the service sector for hospital,
- run a confirmation test of the optimal settings.

In India people visit hospitals both government and private. Their satisfaction is a matter of concern for

Table 1: List of factors with their corresponding levels affecting the services provided by hospital

Identifier for the factors	Factors	Level 1	Level 2	Level 3
A	To what extent a hospital should be subsidized?	Highly subsidized	Moderately subsidized	Low subsidized
B	Is it necessary that doctors should give consultation on time?	Extremely necessary	Necessary	Sometimes
C	Is it necessary that doctors should be highly qualified?	Extremely necessary	Necessary	To some extent
D	Should the patient receive the right treatment which is fit for them?	Extremely necessary	Necessary	
E	Should Research and Development be done with the consent of the patients?	Highly agree	Agree	Moderately agree
F	Should the hazards be intimated to the patients?	Extremely necessary	Necessary	Not Necessary
G	How good should the postoperative care be?	Very good	Good	Moderate
H	How important is the availability of the doctor?	Extremely important	Important	To some extent

healthcare institutions. To convert this issue in quantitative terms, a questionnaire-based survey has been administered to the stakeholders.

The questionnaire was prepared in 2 parts - (i) observation part and (ii) expectation part. This approach is very similar to the approach suggested by Beach and Burns (1995b). The authors discussed about services offered by the organization (now) and how it (ought) to address them. As respondents opted for their suitable options and filled the questionnaire, satisfaction was measured by comparing the evaluation of expectation (ought) and experiences (now).

Identification of factors from customer's point of view: After receiving the filled in questionnaire, the gathered information is analysed through Ishikawa or cause-effect (fish-bone) diagram (**Figure 1**). In the cause-effect diagram, all the causes are analysed by comparing the expectations and observations for the effect of dissatisfaction of the customers. Only those important factors/causes are selected where the **observation < expectation,** which means the patients are dissatisfied with the services provided by the hospital. Beach and Burns (1995) discussed this method of measuring the customer's satisfaction. The important factors emerged are given in Table 1 with their respective levels and the factors are assigned alphabet identifiers viz. A, B, C, D, etc. for further discussions.

Selection of the Orthogonal Array: In order to choose an appropriate orthogonal array, degrees of freedom are calculated. Since there are 7 factors each at 3 levels and 1 factor at 2 levels, therefore, the total degrees of freedom required is

$7(3-1) + 1(2-1) = 14 + 1 = 15$ d.f. Also, since, there are factors at 2 and 3 levels, L_{18} O.A. is chosen. 2 d.f. is assigned to errors. Table 2 shows the experimental design for an L_{18} orthogonal array.

Table 2: L_{18} orthogonal array of Taguchi's experimental design

	Factor Identifier							
Runs	1	2	3	4	5	6	7	8
1	1	1	1	1	1	1	1	1
2	1	1	2	2	2	2	2	2
3	1	1	3	3	3	3	3	3
4	1	2	1	1	2	2	3	3
5	1	2	2	2	3	3	1	1
6	1	2	3	3	1	1	2	2
7	1	3	1	2	1	3	2	3
8	1	3	2	3	2	1	3	1
9	1	3	3	1	3	2	1	2
10	2	1	1	3	3	2	2	1
11	2	1	2	1	1	3	3	2
12	2	1	3	2	2	1	1	3
13	2	2	1	2	3	1	3	2
14	2	2	2	3	1	2	1	3
15	2	2	3	1	2	3	2	1
16	2	3	1	3	2	3	1	2
17	2	3	2	1	3	1	2	3
18	2	3	3	2	1	2	3	1

The assignment of factors to various columns is accomplished as follows: since factor D is at 2 levels, it is assigned to column 1, other factors are thereafter assigned to column 2 to 8 arbitrarily – factor C to column 2, factor A to column 3 and so on.

Conducting Requirements: For each run the response is calculated. Since we opted for L_{18} O.A., there are 18 runs and the experiment is done without replication as dictated by the L_{18} array of Table 2. The signal to noise ratio is also calculated. As our quality

characteristic is Larger the better, Signal-to-noise ratio is calculated as

$$S/N_{(LTB)} = -10 \log_{10}\left(\frac{1}{n}\sum\frac{1}{y_i^2}\right).$$

Results are shown in Table 3.

Table 3: Response under various Trials/Runs.

	Factor identifier								
Runs	D	C	A	B	E	F	G	H	Response
1	1	1	1	1	1	1	1	1	173
2	1	1	2	2	2	2	2	2	169
3	1	1	3	3	3	3	3	3	120
4	1	2	1	1	2	2	3	3	149
5	1	2	2	2	3	3	1	1	186
6	1	2	3	3	1	1	2	2	139
7	1	3	1	2	1	3	2	3	157
8	1	3	2	3	2	1	3	1	133
9	1	3	3	1	3	2	1	2	193
10	2	1	1	3	3	2	2	1	185
11	2	1	2	1	1	3	3	2	193
12	2	1	3	2	2	1	1	3	159
13	2	2	1	2	3	1	3	2	172
14	2	2	2	3	1	2	1	3	167
15	2	2	3	1	2	3	2	1	210
16	2	3	1	3	2	3	1	2	185
17	2	3	2	1	3	1	2	3	161
18	2	3	3	2	1	2	3	1	212

S/N (LTB) = 44.32108387db

Analysis of Variance

Based on the responses in Table 3, to investigate the average effect of seven 3 level factors and one 2 level factor, the Taguchi experiment is carried out. The analysis is done using single run. The factor averages at each factor level are obtained by adding the results of all trial conditions at the level considered and then dividing by the number of data points added. For example

$$\bar{A}_1 = (y_1 + y_4 + y_7 + y_{10} + y_{13} + y_{16})/6$$

Similarly, the other average effects are calculated by using the same concept. The results are given in Table 4.

Ignoring any interaction effects and considering the "larger the better" characteristic which is desired in this case, the optimum condition becomes:

$$\bar{A}_3 \quad \bar{B}_1 \quad \bar{C}_3 \quad \bar{D}_2 \quad \bar{E}_1 \quad \bar{F}_2 \quad \bar{G}_1 \quad \bar{H}_1$$

In the next step, the Analysis of Variance is conducted to establish the relative significance of the individual factors. The steps considered are:

Total of all results = 3063

Correction factor = 521220.5

Here total number of experiments is n = 18.

Total sum of squares = 10792.5

Now the ANOVA table is prepared for further analysis. The result is given in Table 5.

At the outset, a significance level of 0.01 (confidence level of 99 per cent is considered) is set as the cut off point for pooling an effect into error. The ANOVA table is developed as follows: the first column is simply the factor identifier, the second column is the sum of squares for each factor, third column is the degrees of freedom for each factor and the final column is developed by simply finding the percentage of each sum of square with respect to the total sum of squares of all the factors. In an attempt to find factors that can

Table 4: The average effect of the various factors

Average effects	A1bar	A2 bar	A3 bar	B1 bar	B2 bar	B3 bar	C1 bar	C2 bar	C3 bar
Values	170.1667	168.1667	172.1667	179.8333	175.8333	154.8333	166.5	170.5	173.5

Average Effects	D1bar	D2 bar	E1 bar	E2bar	E3bar	F1bar	F2bar	F3bar
Values	157.6667	182.6667	173.5	167.5	169.5	156.1667	179.1667	175.1667

Average effects	G1bar	G2bar	G3bar	H1bar	H2bar	H3bar
Values	177.1667	170.1667	163.1667	183.1667	175.1667	152.1667

be pooled in the error, as a first step, all factors that contributed less than or equal to 1% to the overall sum of squares are pooled into the error term. Thus the factor A, C and E are found insignificant as their contribution is either less than 1 per cent or equal to 1 per cent.

Table 5: The first ANOVA table before pooling the insignificant factors

S.V.	S.S.	D.F.	Percent contribution
Due to A	48	2	0.004447533
Due to B	2164	2	0.200509613
Due to C	148	2	0.013713227
Due to D	2812.5	1	0.260597637
Due to E	112	2	0.010377577
Due to F	1812	2	0.167894371
Due to G	588	2	0.054482279
Due to H	3108	2	0.287977762
Due to Error	0	2	Indeterminate
Total	10792.5	17	

Variance column in the final ANOVA given in Table 6 is computed by dividing sum of squares by degrees of freedom for the corresponding unpooled factor/error term. F values are computed by dividing the variance of the factor under consideration by error variance. These F values are compared against the F values provided for 1 per cent significance in appropriate tables. The effect of B, D, F and H are significant at 99 per cent confidence interval but strictly speaking factor G is not significant at 99 per cent confidence interval since the tabulated F value (2,8) d.f. equals to 8.6491 which is larger than 7.6363. The team members strongly felt that it is a significant factor and should be included in the derived model.

Table 6: The final ANOVA after pooling the insignificant factors A, C and E

S.V.	D.F.	S.S.	M.S.S.	P.C.	V.R.
Due to B	2	2164	1082	0.20051	28.1038961
Due to D	1	2812.5	2812.5	0.260598	73.05194805
Due to F	2	1812	906	0.167894	23.53246753
Due to G	2	588	294	0.054482	7.636363636
Due to H	2	3108	1554	0.287978	40.36363636
Pooled Error	8	308	38.5	0.028538	
Total	17	10792.5		1	

The combination that yields the largest value of S/N is determined from the above analyses is as follows:

Factor:	B	D	F	G	H
Optimal	1	2	2	1	1

Thus $B_1\ D_2\ F_2\ G_1\ H_1$ provides the best combination, which means that, stakeholders i.e. the patients feel that it is extremely necessary that doctors should be available in the hospital and must give consultation on time. It is also necessary that they should get the right treatment, which is fit for them, and that the hazards/side effects of the treatment should be informed to them. As far as the post-operative care is concerned it should also be good.

Confirmation test

Based on the optimal combination, the grand average of the performance $\bar{T}$ is computed.

$$\bar{T} = 170.1666667$$

Considering only the significant factors, $B_1\ D_2\ F_2\ G_1\ H_1$, the performance at the optimum condition is also estimated using only these five factors.

$$\bar{T} + (B_1 - \bar{T}) + (D_2 - \bar{T}) + (F_2 - \bar{T}) + (G_1 - \bar{T}) + (H_1 - \bar{T})$$

$= 223.3333$db (the optimum condition for the 'larger the better' quality characteristic is $B_1\ D_2\ F_2\ G_1\ H_1$)

Discussion and conclusion

The study is aimed to focus on understanding the right way to reduce the gap between the expectation and experiences/observations of the patients of hospital services. This is accomplished by developing a model using Taguchi's robust design technique. The analysis is based on maximizing the S/N ratio for effectively redressing the users' complaint.

As a result of the above study, some observations are made for the parameters relating to services rendered by the Indian healthcare sector. Patients feel that the regular consultation on time is the top-most concern. Unfortunately, majority of the rural population in India is deprived or scantily served on this score. Availability of the right doctors is important from the patients' perspective. There is a need to look at the issues of non-availability or over burdened specialist doctors in a majority of government hospitals. Also the issue of quacks cheating the patients is counter to what patients expect from this sector. A hospital must see that these basic facilities are available to their patients. Patients also feel that they should get the right treatment, which directly affects the post-operative care.

They should also be informed about the medical hazards and side effects of the drugs or treatment. The hospital management can actually increase the safety level by keeping its patients well-informed. Active participation of the patients is a pre-requisite to an effective post-operative care process. Caregivers can actually add value to this. Though this study is limited to the Indian health care system, the model can be extended to similar service sectors too.

References

Arnesen T. and Trommald M. (2004), "Roughly right or precisely wrong? Systematic review of quality-of-life weighs elicited with the time trade-off method", Journal of Health Service Research Policy, Vol 9, No 1, January 2004.

Beach, R.L. and Burns, R.L. (1995), "The Service quality improvement strategy: Identifying priorities for change", International Journal of Service Industry Management, Vol 6, No 5, (5-15).

Celia Davis (2004), "Regulating the healthcare workforce: next steps for research", Journal of health service research policy, Vol 9, Suppl 1, January 2004.

Holscomb C.M. (1994), "Customer service measurement: A methodology for increasing customer value through utilization of the Taguchi strategy", Journal of business logistics, Vol 15, No 1.

Kethley B.R., Waller D.B. and Festervand A.T. (2002), "Improving customer service in the real estate industry: A property selection model using Taguchi loss functions", Total Quality Management, Vol 13, No 6, (739-748).

Lewis R.C. and Booms B.H. (1983), "The Marketing aspects of service quality, Engineering perspectives on services marketing", American Marketing, (99-107).

Martin D., Abelson J and Singer P. (2004), "Participation in healthcare priority-setting through the eyes of the participants", Journal of health service research policy, Vol 7, No 4, October 2002.

Palanikumar K. and Karunamoorthy L. (2003), "Design Optimization for Quality in Machining Process using Taguchi Approach", Productivity, Vol 44, No 1.

Parasuraman A, Zeithaml A.V. and Berry L.L. (1985), "A conceptual model of service quality and its implications for future research", Journal of Marketing, Vol 49, 1985, (41-50).

Roy K Ranjit (1990), "A Primer on the Taguchi Method ", Publisher: Society of Manufacturing Engineers, 1990.

Staat, M. and Hammerschmidt M. (2000), "Benchmarking the health sector in Germany – An application of Data Envelopment analysis", Research Paper, Institute for Market-Oriented Management, University of Mannheim, October 2000.

Taguchi, G. (1959), "Linear Graphs for Orthogonal Arrays and their Application to experimental Design, With the Aid of Various Techniques", Reports of Statistical Application Research JUSE, 6, (1-43).

Taguchi, G. (1987), "System of Experimental Design: Engineering Methods to optimise Quality and Minimize Cost", White Plains, NY: UNIPUB/Kraus International, 1987.

□

Striving for success without hard work is like trying to harvest when you haven't planted.

– David Bly

Feature

Impact Evaluation of Integrated Pest Management (IPM) Technology on Cotton Productivity in Punjab

Nirmal Singh, Sukhpal Singh & Satwinder Singh

The present study was undertaken to evaluate the impact of IPM cotton production technology on cotton productivity in cotton based cropping system of Punjab during 2003-04. The quantity of pesticides (Technical Grade) used for growing one hectare of cotton was 4.74 kg by IPM farmers and 10.76 kg by Non-IPM farmers. Moreover the later category of farmers used mostly the synthetic pyrethroids/mixture of pesticides, which were against the university recommendation. An increase in production of 359 kg/ha by using half the pesticides, an increase in employment earnings of about Rs. 1070/ha as gains to the society and an increase of about Rs. 7248/ha in net returns to farmers as the returns to IPM in cotton is, too, much to be sacrificed. Hence this technology needs to be further promoted during cotton growing season through various extension programmes. This technology will enhance productivity of cotton on sustainable basis with lower cost of production and will reduce the indiscriminate use of chemical pesticides which in turn will protect the environmental health.

Nirmal Singh is a Senior Statistician, Sukhpal Singh is an Agricultural Economist and Satwinder Singh is a research associate, Department of Economics, Punjab Agricultural University, Ludhiana.

Cotton popularly known as 'white gold' is one of the principal commercial crops of India. India has the largest area (26 per cent) under this crop but due to low productivity, its contribution towards the total world production is only 12 per cent. Although, there has been a significant growth in productivity (from 88 kg to 319 kg per hectare) during the last 50 years, it is still much below the world average of 558 kg/ha, and is negligible compared to high productivity countries like Australia (1659 kg/ha), Israel (1361 kg/ha) and China (1102 kg/ha).

Visualising an average per capita per annum domestic requirement of cloth to be 21.5 metres along with maintaining of cotton/textiles export potentials in the WTO regime of liberalised trade, the production targets have been fixed at 20 million bales for the year 2005 and 25 million bales for the year 2025 against the current production level of 16.5 million bales (Mayee, 2003). To attain these production targets, the Government of India decided to follow the "Mission Mode" approach, which had shown spectacular results in enhancing oilseed production during the 1990s. The main objective of Mini Mission 1 under Technology Mission on Cotton (TMC) is to improve cotton productivity, reduce the cost of cultivation by evolving new short duration varieties and developing new cotton production technologies such as IPM, IRM, INM, etc.

The Northern Zone (Punjab, Haryana and Rajasthan) produces about 35 per cent of the total cotton production of India. The total loss due to cotton pests (Jassid, Whitefly and bollworms complex) in this zone is 52.8 per cent compared to 46.8 per cent in Central Zone (Narula 2001). In this zone, an overview of cotton crop in the Punjab state shows that the state, having primary irrigated crop, has been leading the country for several years both in productivity as well as share in national

production. Cotton production in Punjab state touched all-time high of 26 lakh bales in 1991-92. However, its cultivation is in danger since the beginning of the 1990s as the crop area declined from 743.9 thousand hectares in 1990-91 to 473 thousand hectares in 2000-01. To sustain the production levels, farmers used pesticides indiscriminately to control the key pests i.e. bollworm complex (American bollworm, Spotted bollworm, Pink bollworm) etc, leading to higher cost of cultivation and lower new returns. According to Dhaliwal and Arora (1996), although the pesticide consumption in India is low (570 gm/ha) compared to other developed countries like Japan (11 kg/ha), Taiwan (17 kg/ha) etc, the problems as a result of injudicious use are quite alarming. This could be attributed to their uneven distribution and usage on selective crops. About 84 per cent of total pesticides are consumed on cotton (54%), rice (17%) and vegetables and fruits (13%), though the area under these crops is only 5, 24 and 3 per cent, respectively (GOI, 1997). Efforts have been launched to bring down the pesticide consumption rate in cotton to 20 per cent (Mayee, 2002), which will have a direct bearing on cotton cultivation and quality of cotton. IPM is one of the alternate technologies developed for sustaining cotton production by reducing the indiscriminate use of pesticides. This is a pest management system that in the context of the associate environment and the population dynamics of the pest species, uses all the suitable techniques and methods in as compatible a manner as possible and maintains the population of pests at levels below those causing economically acceptable damage or loss. The suitable techniques involve physical, cultural, biological and chemical methods.

Pesticide consumption in Punjab increased from 3200 MT of technical grade in 1980-81 to 7200 MT in 2001-02, registering a growth rate of about 4 per cent per annum. During 2001-02, assuming 50 per cent consumption on cotton, the per hectare pesticide consumption (Technical Grade) on this crop was 11.86 kg. It indicated the extent of degradation of agricultural environment by this poison in the cotton belt of the state. Keeping in view the importance of this technology in controlling indiscriminate pesticide use for sustaining cotton productivity, an attempt has been made to evaluate the impact of IPM technology at farmers' fields in the Punjab State. More specifically the objectives of the present investigation were; (a) to examine the socio-economic status of the adopters and non-adopters of cotton IPM technology in the Punjab State, (b) to study the impact of this technology on fertilizer, labour and pesticides use on cotton among these two categories of cotton growers and (c) to evaluate the economic viability of this technology.

Methodology

Data used in this investigation was collected under the project, "Evaluation of Cotton Production Technologies for Yield, Fibre Quality and Economic Viability (TMC-MM5.1)" and pertains to the crop year 2003-04. To demonstrate IPM technology at farmers fields, the Department of Entomology, Punjab Agricultural University, Ludhiana, adopted a number of villages in the cotton belt of the Punjab state. Kahnewal of district Mansa was one of these villages, which was selected for the above project. A list of farmers who have adopted IPM technology in cotton was taken from the concerned entomologists of the department and ten farmers were selected randomly from this list. With-without approach of evaluation was used and ten farmers with almost identical farm sizes from the nearby Kot-Dharmu village of the same district were selected. Moreover, to eliminate the varietal differences in the case of hybrid as well as non-hybrid cotton, control plots (Non-IPM farmers) and experimental plots (IPM farmers) were taken of the same variety. Data pertaining to all inputs and output during cotton cultivation on the experimental and control plots was collected from all the 20 farmers using well structured and pre-tested schedule. In addition to his data, information was also collected on the socio-economic characteristics of the respondents. For working out the gross returns, the actual price of cotton received by the farmers in the market was used. Variable expenditure on cotton which included seed, fertilizers, insecticides/pesticides, human/machine/bullock labour (owned and hired), irrigation costs etc, along with 12 per cent interest on working capital, were subtracted from the gross returns (Total value of main product and by-product evaluated at the market prices) to get the net returns from the cotton crop.

To achieve the stipulated objectives, data was analysed using simple tabular analysis and statistical significance of differences between the IPM farmers and Non-IPM farmers was tested using t-statistic.

Findings

Socio-economic Status of Sampled farmers

The results presented in Table 1 pertain to the socio-economic status of adopters and non-adopters of IPM technology. The per farm operational area worked out to be 4.15 hectares and 4.46 hectares for adopters and non-adopters of IPM technology respectively. Though the operational area per farm was found to be almost the same for these two categories, the percentage of leased in land was more on Non-IPM farmers (11.98%) than the IPM farmers (4.37%).

Table 1: Socio-economic status of IPM and Non-IPM sampled cotton growers, cotton based cropping system, Punjab, 2003-04

S. No.	Particulars	Units of measurement	IPM	Non-IPM
1.	Operational area	Ha/farm	4.15	4.46
2.	Leased-in land	Per cent	4.37	11.98
3.	Family size	No\farm	6.1	6.8
4.	Education level of head of the family	Average score*	1.4	0.6
5.	Investment in farm machinery & equipment	Rs./ha	20173	23816
6.	Adoption of hybrid technology (growers)	Per cent	40.0	40.0
7.	Area under cotton			
	a. Total	Hectare	2.56 (61.9)	1.92 (43.1)
	b. Area under hybrid cotton	Per cent of total cotton area	28.9	16.3

* Education scoring was illiterate = 0, Primary = 1, Matric = 2 and Post Matric = 3

Figures in the parentheses indicate percent area under cotton.

The family size was found to be 6.1 and 6.8 respectively for IPM and non-IPM farmers. Noticeable differences in teh educational level of the head of the family of these two categories were observed as the average education score was much higher for IPM farmers (1.4) than for the Non-IPM farmers (0.6). The investments in farm power and machinery were the other way round i.e. these were higher for non-IPM (Rs. 23816/ha) than that of the IPM farmers (Rs. 20173/ha). The proportion of area under cotton was more on IPM farmers (61.7%) than the non-IPM farmers (43.1%). Due to short duration and higher yields, hybrid cotton, irrespective of higher seed costs was being adopted by the cotton growers in Punjab on a large scale. The adoption rate of this technology was much higher on IPM (28.9% of total area) as compared to non-IPM farmers (16.3% of total area). Thus, the IPM farmers had a higher education level and higher rate of adoption for high yielding varieties of cotton but had lower investments on farm power and machinery.

Physical inputs used for cotton cultivation

As the input requirements vary with variety, the physical input data was analysed separately for hybrid and non-hybrid cotton. Cotton area for experimental plots (IPM) and control plots (non-IPM) was 0.40 and 0.32 ha/farm respectively for hybrid cotton (Table 2). The corresponding figures for non-hybrid cotton were 0.36 and 0.62 ha/farm respectively.

Table 2: Fertilizer used for cotton cultivation by IPM and Non- IPM sample farmers in cotton based cropping system, Punjab 2003- 04.

Particulars	Units of measure-ment	IPM	Non-IPM	Change over Non-IPM (%)
Hybrid cotton				
Area	Ha/farm	0.40	0.32	–
Fertilizer				
Quantity	Kg/ha	–	–	–
N	Kg/ha	79.46(53.37)	52.46,(35.13)	+51.47
P_2O_5	Kg/ha	47.72(160)	36.65(123.33)	+30.20
Total	Kg/ha	127.18	89.11	+42.72
Expenditure	Rs./ha	1528	1124	+35.91
Percent to total expenditure	Per cent	8.19	7.01	–
Non-hybrid cotton				
Area	Ha/farm	0.36	0.62	–
Quantity	Kg/ha	–	–	–
N	Kg/ha	71.97(97.29)	55.08(74.32)	+30.66
P_2O_5	Kg/ha	27.76(93.33)	36.93(123.33)	-24.83
Total	Kg/ha	99.73	92.01	+8.39
Expenditure	Rs./ha	1130	1143	-1.14
Percent to total expenditure	Per cent	7.05	7.54	–
Overall				
Area	Ha/farm	0.76	0.94	–
Quantity	Kg/ha	–	–	–
N	Kg/ha	75.95	54.22	+40.07
P_2O_5	Kg/ha	38.26	36.85	+3.83
Total	Kg/ha	114.21	91.07	+25.41
Expenditure	Rs./ha	1340	1137	+17.85
Percent to total expenditure	Per cent	7.70	7.36	–

Figures in the parentheses indicate the percent adoption to the recommended fertilizer dose of N and P_2O_5.

Fertilizer Use

Fertilizer is a crucial input on which cotton output depends. Table 2 shows that on overall basis fertilizer used by IPM farmers was higher both quantity wise (about 25%) and cost-wise (about 18%) than non-IPM farmers. Fertilizer share in total expenditure was to the tune of 7.70 per cent on IPM farmers and 7.36 per cent

on non-IPM farmers. Nutrient-wise former category of farmers used about 76 kg of nutrients on growing one hectare of cotton, which was about 40 per cent more than the latter category. Both categories of farmers used N less than its recommended dose.

Table 3: Human labour used for cotton cultivation by IPM and Non-IPM sample farmers in cotton based cropping system, Punjab, 2003- 04.

Particulars	Units of measurement	IPM	Non-IPM
Hybrid cotton			
Family labour	Man days/ha	13.86	16.40
Hired labour	Man/days/ha	63.75	43.0
Total	Man/days/ha	77.61	59.40(30.7)
Expenditure	Rs./ha	5065.48	4103.94
Percent to total expenditure	Per cent	27.18	25.62
Non-hybrid cotton			
Family labour	Man days/ha	19.56	20.73
Hired labour	Man/days/ha	48.20	25.40
Total	Man/days/ha	67.76	46.13(46.9)
Expenditure	Rs./ha	4505.55	3375.23
Percent to total expenditure	Per cent	28.13	22.27
Overall			
Family labour	Man days/ha	16.50	20.67
Hired labour	Man/days/ha	56.40	30.68
Total	Man/days/ha	72.9	51.35(42.00)
Expenditure	Rs./ha	4800.25	3730.47
Percent to total expenditure	Per cent	27.59	24.15

Figures in the parentheses indicate percent change over IPM

The use of P_2O_5 was more than the recommended dose of 30 kg per ha for cotton cultivation. Strikingly, the IPM farmers used a much higher dose of P_2O_5 on hybrid cotton at about 48 kg/ha, compared about 28 kg/ha used on non-hybrid cotton. Its use on non-IPM farmers was about 37 kg per hectare on hybrid as well as non-hybrid cotton. Variety-wise, fertilizer input analysis on IPM as well as non-IPM farmers showed a very imbalanced use of both N and P_2O_5 nutrients for cultivating hybrid cotton. IPM farmers used 127 kg of fertilizer (about 43 per cent more than the non-IPM farmers) in growing one hectare for hybrid cotton. Nutrient-wise both the categories used more than the recommended dose of P_2O_5 (30 kg/ha). As compared to this, use of N was much below the recommended dose on both categories i.e. IPM (47%) as well as non-IPM farmers (65%). This input analysis showed that the farmers needed to be educated on balanced fertilizer dose for hybrid technology to get optimum crop yields and reduce the cost of cultivation.

Labour Use

Cotton plays an important role in the development of the Indian economy especially by providing large employment on farm, marketing and the processing sector. An attempt was made to estimate the labour use while cultivating cotton with and without this technology. It can be seen from Table 3 that on an overall basis, human labour employed per hectare of cotton was about 73 man days on IPM farms, which was about 22 man days more than that of the non-IPM farmers. The returns to this additional labour use (family/hired), worked out to be about Rs. 1070 per hectare. Share of labour cost in the total expenditure on crop cultivation was about 28 per cent on IPM farmers and 24 per cent on non-IPM farmers. Variety-wise these differences in labour use were higher for non-hybrid which covered about 60 per cent of the area under cotton in the state. The reason for this significant difference in labour use was the better crop harvest by IPM farmers. Thus, the adoption of this technology can generate about 11 million man-days more on-farm employment from about 5 lakh hectares of cotton area in the state.

Pesticide Use

Pesticide use is rapidly increasing and adversely affecting human health and the agricultural environment. Cotton crop is the largest consumer of pesticides in India. Indiscriminate use of these pesticides in cotton cultivation has caused several negative externalities in farm and non-farm sectors (Painuly, 1998). The main objective of IPM technology in cotton is to obtain sustainable cotton production by reducing the indiscriminate use of pesticides.

The perusal of Table 4 shows the extent and pattern of the pesticides used by the adopters and non-adopters of IPM technology in cotton cultivation. Quantity of pesticides (Technical Grade) used in cotton cultivation by IPM farmers was 4.74 kg per unit area which was less than half of the quantity used by non-IPM farmers (10.76 kg). Variety-wise the results were similar. Pesticide use on hybrid cotton was less as compared to non-hybrid cotton on both types of the farms. The modal number of sprays on cotton was estimated to be 9 for IPM and 12 for noon- IPM farmers (Fig. 1), but the per spray cost was higher on the former category farms due to significantly different use pattern. The share of plant-protection cost (pesticides) in total expenditure worked out to be 38.3 per cent on IPM and 44.5 per

cent on IPM and 44.5 per cent on non-IPM farmers in the state.

Table 4: Extent and pattern of pesticides used on cotton by IPM and Non-IPM farmers in cotton based cropping system, Punjab, 2003-04.

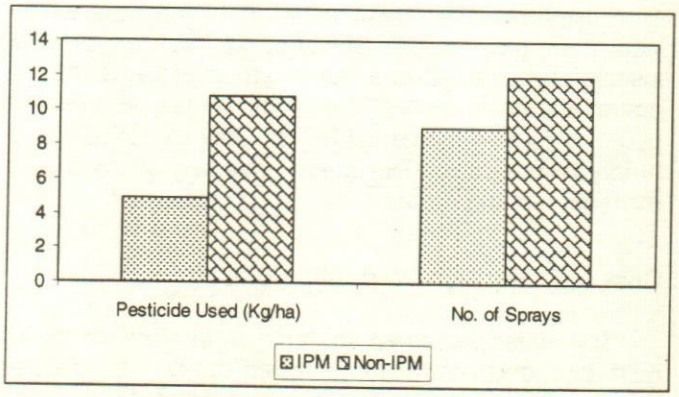
Pesticide used	IPM			Non-IPM		
	Hybrid cotton	Non-hybrid cotton	Overall	Hybrid cotton	Non-hybrid cotton	Overall
Do not use						
Karate	–	–	–	–	0.91	0.8
Omit 505 (Cyper + Ethion)	–	–	–	51.19	50.32	50.4
Cypermethrin	2.93	5.38	4.8	15.83	13.67	14.0
Fenvil	–	0.3	0.17	–	–	–
Use sparingly						
Accephate	11.53	3.97	5.7	3.37	0.59	1.0
Ekalux	5.72	4.05	4.4	6.19	7.29	7.10
Chloropyriphos	4.29	8.28	7.4	–	0.2	0.2
Trizo/Hostathion/ Sutathion	22.12	22.22	22.13	12.12	20.86	19.6
Endosulfain	23.98	19.55	20.6	–	–	–
Tracer	1.32	0.91	0.1	1.68	–	0.2
Avaunt	8.23	6.33	6.8	1.34	–	–
Ektara/Confidor	1.10	0.92	1.0	–	0.22	0.19
Use as required						
Ethion	14.25	24.66	22.4	–	–	–
Alpha	4.51	3.39	3.6	–	–	–
Monocrotophos	–	–	–	8.25	5.89	6.20
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total pesticides* (kg/ha)	4.31	4.89	4.74	9.48	10.99	10.76
No. of sprays	9	9	9	12	12	12
Total expenditure (Rs./ha)	6699 (35.9)	6643 (41.97)	6672 (38.3)	6753 (42.2)	6931 (45.7)	6872 (44.5)
Rs./spray	744	738	741	563	578	573

*Total pesticides used in Technical Grade kg/ha of cotton
Figures in the parentheses indicate percent change over IPM

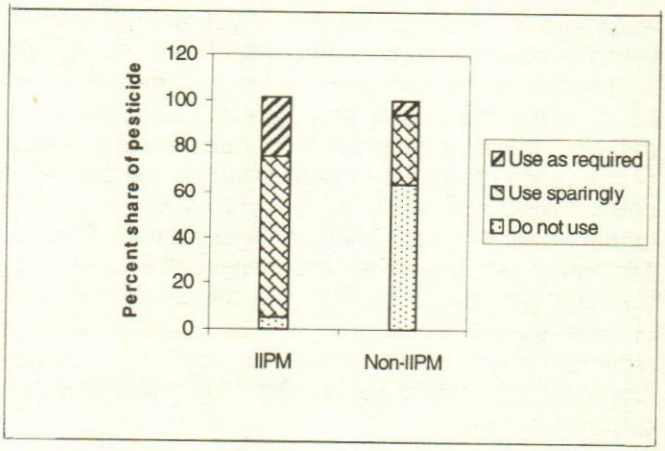
The foregoing analysis revealed that the IPM farmers not only used less number of sprays, they also used less chemical per spray than the non-IPM farmers. Thus the adoption of this technology significantly reduced the extent of pesticides use and the number of sprays, leading to a quality harvest with better returns.

Pattern of Pesticides used in Cotton Cultivation

Pesticides continue to be a major component of IPM owing to several constraints such as use of cultural practices, the availability of resistant cultivars, effective parasitoids and microbes. On the basis of the experiments, experts recommend the selection of a pesticide along with its dose, time, and method of application etc, to control the pest complex of cotton eco-system during the vegetative (Jassid and white fly) and flowering phase (bollworms and white fly). A large number of pesticides are available in the market. The pattern of these pesticides in the total pesticide consumption on cotton cultivation is also given in Table 4. The IPM farmers got expert guidance, leading to the judicious use of these pesticides by following economic threshold levels (ETL) for different insect pests of cotton, especially during the flowering stage, whereas non-IPM farmers used these poisons on the recommendations of the traders'dealers having profit motives.



A: Pesticide use



B: Use pattern

Fig. 1.

The main pesticides recommended by the Punjab Agricultural University are Imidaclopride200SL/Acetamiprid20SP/Thiametheoxan 200WP for jassid control

and Endosulfan35EC/Chlorophyriphos20EC/ Trizo-phos 40EC/Indoxacarb15SC/Spinosad48SC/Quinalphs20EC/ Ethion40EC/Accephate75SP etc for bollworm control. However, the PAU discourages the use of synthetic pyrethroids and a mixture of insecticides. It was observed that the IPM farmers mostly used the latest recommended pesticides like Confidor/Avaunt/Tracer/ Accephate etc. Although these pesticides increased significantly the per spray cost (however likely to decrease in future) on these farms, they were very effective in controlling the cotton pests. Half of the pesticides used by non-IPM farmers were a mixture of insecticides, which was against the University recommendation. Use of synthetic pyrethroids on these farms was almost three times than the former category. Thus, the extent and use pattern of the poisons in cotton cultivation by the average cotton growers in Punjab indicated that the total quantity per unit area was much higher and both selection and dose of these pesticides was not proper. They used mostly synthetic pyrethroids/ mixtures, which lead to the development of insecticide resistance in the insects and also led to a deterioration of the quality of cotton and environment. The excessive use of synthetic pyrethroids also increased the severity of Whitefly and American bollworm. This is turn adversely affected pest management in cotton.

Cost of Cultivation/Production of Cotton

The data presented in table 5 exhibits costs of cultivation and production incurred during the production process of raw cotton with and without IPM technology. The results indicate that the per hectare cost of cultivation for both hybrid and non-hybrid cotton was more for IPM farmers (Rs. 18635 and Rs. 16018) than the non-IPM farmers (Rs. 16017 and Rs. 15156). In the new world economic order, our interest would be to make the cotton crop globally competitive by reducing the cost of production rather than the cost of cultivation. The cost of production of one quintal of cotton was estimated to be Rs. 1088 with IPM farmers and Rs. 1246 with non-IPM farmers. Thus in addition to being environment friendly, this technology was cost effective, thus reducing the production cost of one quintal by about Rs 158. Variety-wise the reduction in per quintal production cost of cotton was higher for non-hybrid cotton (Rs. 164) than the hybrid cotton (Rs. 103).

Coefficient of variation (CV) was worked out to examine the extent of variability in per hectare cost of cultivation and per quintal cost of production. It can be seen from table 5 that the CV's were lower for IPM farmers, indicating more consistency in this category than non-IPM farmers.

Table 5: Cost of cultivation/production of cotton on IPM and Non-IPM sample farmers in cotton based cropping system, Punjab, 2003-04

Particulars	IPM	Non-IPM
Cost of cultivation (Rs./ha)		
Hybrid cotton	18635(3.84)	16017(6.57)
Non-hybrid cotton	16018(6.26)	15156(12.07)
Overall	17395(8.54)	15445(10.22)
Cost of production (Rs./qtl)		
Hybrid cotton	1051(16.27)	1154(21.95)
Non-hybrid cotton	1140(19.05)	1304(10.210)
Overall	1088(18.33)	1246(23.65)

Figures in the parentheses indicate coefficient of variation

Productivity and Economic Returns

The various parameters studied to measure the economic-viability of IPM technology were the productivity, gross returns, net returns and input-output ratio of the cotton grown by the IPM AND non-IPM farmers. The results shown in table 6 indicate that the per hectare cotton productivity was significantly higher (15.98/qtls.) on IPM farmers than the non-IPM farmers (12.39/qtls.). Variety-wise use of this technology increased the crop

Table 6: Impact of IPM technology on productivity and net returns from cotton IPM and Non-IPM sample farmers in cotton based cropping system Punjab, 2003-04.

Particulars	IPM	Non-IPM	t-Statistics
Productivity (kg/ha)			
Hybrid cotton	17.73	13.88(27.7)	2.78*
Non-hybrid cotton	14.05	11.62(29.2)	4.49*
Overall	15.98	12.39(28.4)	3.62*
Gross returns (Rs./ha)			
Hybrid cotton	44390	34462	2.80*
Non-hybrid cotton	35224	29037	4.55**
Overall	40049	30851	3.68**
Net returns (Rs./ha)			
Hybrid cotton	25755	18455	2.79*
Non-hybrid cotton	19206	13881	4.84**
Overall	22654	15406	3.31*
Input-output ratio			
Hybrid cotton	1.38	1.15	–
Non-hybrid cotton	1.20	0.92	–
Overall	1.30	0.92	–

Figures in the parentheses indicate percent change over Non-IPM.
** and * Significant at 0.01 and 0.05 probability level.

yield by 27.7 per cent for hybrid and 29.2 per cent for non-hybrid cotton. These yield differences were statistically significant at 5 per cent and 1 per cent levels of probability respectively. Due to significantly higher cotton yields obtained by the IPM farmers, gross returns of this category were significantly higher than their counterparts. From the farmer's point of view, the most important factor in the adoption of a new technology is its impact on the net income of the farmer. Net return from cotton was worked out after subtracting variable expenditure incurred on growing cotton from the gross return received by the farmers after selling it in the market. The net returns analysis revealed that the IPM farmers got statistically significant higher net returns amounting to Rs. 7300, Rs. 5325 and Rs. 7248 per hectare for hybrid, non-hybrid and overall cotton crop as compared to the non-IPM farmers.

The economic viability of this technology was also examined by computing input-output ratios i.e. the ratio of net returns to expenditure incurred in growing cotton. The farmers covered under IPM technology got higher input-output ratio as compared to non-IPM farmers. It implies that the farmers using IPM technology earned more per unit profit compared to the non-IPM farmers.

Conclusions and Policy Suggestions

It can be safely concluded from the foregoing analysis that adoption of IPM technology in cotton reduced the pesticide use almost to half and increased the productivity of cotton by about 28 per cent. This technology was cost effective which enhanced the net income from cotton by reducing the per quintal production cost. Keeping in view the importance of IPM in cotton, the largest consumer of pesticides, all-out efforts should be made by the agricultural extension workers to educate the farmers about the role of predators and parasitoids, ETL for various pests, use of bio-pesticides, etc. Therefore, the IPM technology needs to be further promoted during the cotton growing season through various extension programmes like use of information technology, radio/TV talks, farmer's training etc.

An increase in production of 359 kg/ha by using half the pesticides, an increase in employment earnings of about Rs. 1070/ha as gains to the society and an increase of about Rs. 7248/ha in net returns to farmers as the returns to IPM technology in cotton is too much to be sacrificed. Visualising its adoption on about 5 lakh hectares of area under cotton in Punjab, this comes to an increase of about 1.8 lakh tonnes of cotton production (which would feed the state treasury through market tariffs by about Rs. 552 million), which will generate incremental employment worth of Rs. 535 million and increase cotton producer's net incomes by more than Rs. 300 crores every year. This technology will enhance the productivity of cotton on a sustainable basis with lower cost of production and it will also reduce the use of chemical pesticides, which in turn will protect the environmental health and economic condition of the debt-ridden peasantry of the state.

References

Basu A.K., Narayanan S.S. and Phundan (1992), "Cotton production and improvement in India", Agril. Sit in India 47(5): 365.

Dhaliwal G.S. and Ramesh Arora (1996), "Principles of insect management" p. 374, National Agricultural Technology Information Centre, Ludhiana.

Govt. of India (1997), "Agricultural Situation at a Glance", pp. 148, Directorate of Economics and statistics, Ministry of Agricultural, Govt. of India.

Mayee C.D. (2003), "Annual Report of Technology intervention and socio-economic analysis in cotton based cropping system for year 2002-03", CICR, Nagpur.

Narula M. et al (2001), "Cotton insects and diseases: Identification and management", Kapas Vikas Nidheshalaya GOI, Ministry of Agricultural, Dept. of Agril. and Co-operation, Mumbai.

Painuly J.P., Dev S.M. and Reddy B.S. (1998), "Environmental dimensions of fertilizer and pesticide use", relevance to Indian agriculture, Int. Jour, of Environment and Pollution 10(2): 273- 88.

Singh R.P. and Lal R. Singh (1998), "Cotton development and export potential in India—An analysis", Agril.Sit. in India 48(4): 251-56.

□

There are many truths of which the full meaning cannot be realized until personal experience has brought it home.

– John Stuart Mills

Feature

Input-Use Productivity of Wheat Crop in Different Agro-climatic Zones of Punjab

N.S. Dhaliwal, D.K. Grover & R.S. Bawa

This study reveals that the gross returns as well as returns over total costs excluding land in agro-climatic zone II (Central zone) was more as compared to other zones i.e. zone I and III. The study also reveals that the returns over total costs, excluding land in wheat, varied directly with farm size in all the zones. The analysis brought out the need to increase the expenditure on variables on small farms.

N.S. Dhaliwal is Extension Specialist (Farm Management), FASS; Regional Station Faridkot; D.K. Grover is Deputy Director, Agro Economic Research Centre, PAU, Ludhiana; and R.S. Bawa is Registrar/Professor, Punjab School of Economics, Guru Nanak Dev University, Amritsar.

Wheat occupies around 85 per cent of the total cultivated area in the Rabi season in Punjab. Large productivity differentials in wheat have been observed in different agro-climatic zones of Punjab, varying from 3443 to 5169 kg per hectare. Some of the crucial inputs are either under utilized or over utilized in the production process. This inefficiency of resources affects productivity of crops, resulting in an unfavourable cost/returns structure and producer incentives as well. Over the years, productivity deceleration in wheat has also taken place i.e. 10.89 (1975-76 to 1989-90) to 4.99 (1990-91 to 2001-02). In view of the urgency and importance of increasing the food grain production, the resources have to be utilized properly and efficiently. Increasing efficiency of resource use through appropriate allocation not only increases the productivity but also profitability on the farms.

On the basis of topography, climate, soil and water resources, the state has broadly been divided into three zones namely, sub-montane, central plains and south-western zones. The study was located in Punjab as a whole and covered all the three agro-climatic situations of Punjab state. Three districts namely Hoshiarpur, Jalandhar and Muktsar representing sub-montane, central plain and south-western zones respectively were randomly selected to carry out the study. Block-wise area, yield and production of principal crops in selected districts were collected for calculating weighted average productivity. On the basis of weighted average productivity, two blocks from each district i.e. one with the highest productivity (highly developed block) of wheat and another with the lowest productivity (least developed blocks) were selected from each selected district. Thereafter, two villages from each block were randomly chosen.

The present study on wheat is part of a bigger study in which adoption gaps in recommended technology were also examined. For comprehensive investigation, a sample of 59, 58 and 60 farmers were investigated from

three agro-climatic zones of Punjab respectively on the basis of probability proportional to size for the study purpose. The primary information regarding output of wheat and various cost components such as seed, weedicides, micro nutrient, nitrogenous and phosphatic fertilizer, plant protection measures, human labour and machine labour etc. were collected from these 177 farmers for the year 2001-02. The required information on all these aspects was systematically recorded in the schedule especially designed for the purpose, so that it could be logically transformed into different variables.

Functional Analysis

To accomplish the objectives of the study both functional and tabular techniques were used. Economics of wheat cultivation was examined by working out the total cost excluding land on per hectare basis.

To examine the factors affecting value productivity of wheat crop in different agro-climatic zones of state, both linear as well as log linear production function was fitted. The best-fit function i.e. Cobb-Douglas production function was determined on the basis of level of significance of explanatory variable, the value of coefficient of multiple determination (R^2) and the logical signs of the explanatory variable. The following form of Cobb-Douglas function was followed.

$$Y = A \sum_{i=1}^{n} X_i^{bi} U_i$$

where, Y represented value productivity per hectare of wheat, x_i the selected explanatory variables (per hectare), A the technical efficiency parameter and b_i the coefficient of production elasticity of the respective variable x_i at the mean level of input used and output obtained. The 'u_i' is an error term.

The functions were fitted for small, medium and large farms in all the three agro-climatic zones of state.

Y : Value productivity per hectares of wheat (Rs.)

X1: Value of seed (Rs.)

X2: Weedicide (Rs.)

X3: Plant protection measures (Rs.)

X4: Nitrogenous fertilizers (Rs.)

X5: Phosphatic fertilizers (Rs.)

X6: Total labour (Rs.)

X7: Total machine (Rs.)

X8: Irrigation (No.)

X9: Farm size (hectares)

X10: Education (dummy)

X11: Interaction with other agri-related departments (dummy)

The marginal value productivity represents estimated change in gross returns per hectare consequent upon a unit change in the variable under consideration while the level of use of other variables are held constant. Marginal value productivity in the present study was estimated directly from the regression estimates at arithmetic mean level of input and output used as following :

$$MVP_{(xi)} = b_i (\bar{Y}/\bar{X})$$

where, b_i is the output elasticity of variable xi and $\bar{X}$ and $\bar{Y}$ are the arithmetic means of concerned variables.

In the long run, economic losses can be minimized if we reduce the gap between experimental plots and actual farm situations. It is also called yield gap-I. We can overcome this difficulty only by adopting suitable long run policy decisions. In short run, effort can be put to minimize economic losses only by reducing the yield gap II, which was studied by estimating the gap between highest yield and average yield of crops attained in a particular vicinity. Index of yield gap I was estimated by dividing yield gap I with potential yield of wheat.

Economics

An attempt has been made to evaluate the expenditure on small, medium and large farms. Per hectare expenditure on different inputs along with their proportionate share in the total costs excluding land was calculated.

Zone I

Table 1 reveals that the total cost excluding land per hectare for wheat was estimated as Rs. 9205, Rs. 9749 and Rs. 11451 on small, medium and large farms, respectively. The study reveals that the expenditure on human labour in absolute terms varied directly but in relative terms it varied inversely with the size of the farm. The use of machines and fertilizers in absolute as well as in relative terms varied directly with farm size. The returns based on total cost excluding land were observed to be Rs. 5721, Rs. 8595 and Rs. 10059 per hectare on small, medium and large farms, respectively.

Table 1: Economics of wheat cultivation in different agro-climatic zones of Punjab, 2001-02 (Rs. per hectare)

	Zone 1			Zone II			Zone III			Punjab overall		
	Small farmer	Medium Farmer	Large Farmer	Small farmer	Medium Farmer	Large Farmer	Small farmer	Medium Farmer	Large Farmer	Small farmer	Medium Farmer	Large Farmer
Total cost excluding land	9205.22	9749.09	11451.47	14006.02	12662.02	11453.14	10247.44	9795.66	9969.29	11130.25	10770.90	10945.89
Human labour												
Family labour	2428.13 (26.38)	3153.93 (32.35)	1875.89 (16.38)	2211.06 (15.79)	1321.71 (10.44)	648.08 (5.66)	1275.89 (12.45)	962.50 (9.83)	404.46 (4.06)	1954.30 (17.56)	1827.90 (16.97)	984.15 (8.99)
Hired labour	1720.91 (18.69)	1195.72 (12.26)	2791.96 (24.38)	2610.00 (18.63)	1534.08 (12.12)	975.96 (8.52)	842.86 (8.23)	200.69 (2.05)	847.32 (8.50)	1702.55 (15.30)	990.69 (9.20)	1552.13 (14.18)
Total	4149.04 (45.07)	4349.67 (44.62)	4667.85 (40.76)	4821.06 (34.42)	2855.79 (22.55)	1624.04 (14.18)	2118.75 (20.68)	1163.19 (11.87)	1251.78 (12.56)	3656.85 (32.86)	2818.59 (26.17)	2536.28 (23.17)
Machine labour	2019.23 (21.94)	2205.26 (22.62)	2687.50 (23.47)	4749.81 (33.91)	5375.53 (42.45)	5487.50 (47.91)	3598.66 (35.12)	3931.94 (40.14)	3858.04 (38.70)	3459.47 (31.08)	3835.89 (35.61)	3975.00 (36.32)
Seed	1339.90 (14.56)	1278.95 (13.12)	1350.00 (11.79)	1203.08 (8.59)	1142.89 (9.03)	1163.85 (10.16)	1147.95 (11.20)	1172.78 (11.97)	1194.29 (11.98)	1228.25 (11.04)	1198.66 (11.13)	1237.08 (11.31)
Weedicide	209.90 (2.28)	201.71 (2.07)	333.75 (2.91)	453.37 (3.24)	366.45 (2.89)	495.58 (4.33)	567.77 (5.54)	651.53 (6.65)	735.71 (7.38)	414.28 (3.72)	402.19 (3.73)	522.32 (4.77)
Fertilizer												
Nitrogen	496.25 (5.39)	541.20 (5.55)	798.93 (6.98)	858.08 (6.13)	1117.76 (8.83)	965.77 (8.43)	1046.25 (10.21)	1063.33 (10.86)	1048.21 (10.51)	806.34 (7.24)	904.65 (8.40)	936.95 (8.56)
Phosphorus	443.27 (4.82)	572.50 (5.87)	916.96 (8.01)	1016.35 (7.26)	1058.95 (8.36)	1004.04 (8.77)	1130.36 (11.03)	1162.64 (11.87)	1204.29 (12.08)	870.00 (7.82)	927.23 (8.61)	1042.68 (9.53)
Total	939.52 (10.21)	1113.70 (11.42)	1715.89 (14.98)	1874.42 (13.38)	2176.71 (17.19)	1969.81 (17.20)	2176.61 (21.24)	2225.97 (22.72)	2252.50 (22.59)	1676.34 (15.06)	1831.88 (17.01)	1979.63 (18.09)
Manuring	0.00 (0.00)	26.32 (0.27)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	26.32 (0.24)	0.00 (0.00)
Micro nutrients	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	16.35 (0.12)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	30.56 (0.31)	28.93 (0.29)	5.31 (0.05)	9.82 (0.09)	9.88 (0.09)
Plant Protection	6.15 (0.07)	0.00 (0.00)	22.86 (0.20)	0.00 (0.00)	0.00 (0.00)	38.65 (0.34)	34.91 (0.34)	43.4 (0.44)	61.61 (0.62)	14.22 (0.13)	13.97 (0.13)	41.1 (0.38)
Irrigation	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	64.04 (0.46)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	20.81 (0.19)	0.00 (0.00)	0.00 (0.00)
Interest on working capital	541.48 (5.88)	573.48 (5.88)	673.62 (5.88)	823.88 (5.88)	744.84 (5.88)	673.71 (5.88)	602.79 (5.88)	576.22 (5.88)	586.43 (5.88)	654.72 (5.88)	633.58 (5.88)	643.88 (5.88)
Yield value of main product	13076.63	16128.16	19067.21	26548.52	28847.13	31098.96	22698.64	24365.14	25776.72	20822.70	23091.13	25173.21
Value of by product	1850	2215.79	2442.96	4057.64	2963.79	2119.27	2543.59	1540.42	1413.81	2810.24	2252.49	1988.91
Gross Income	14926.63	18343.95	21510.17	30606.16	31810.92	33218.23	25242.23	25905.56	27190.53	23632.94	25343.62	27162.12
Return over total cost excluding land	5721.41	8594.86	10058.70	16600.14	19148.71	21765.09	14994.79	16109.91	17221.24	12502.69	14572.72	16216.23

Figures in parenthesis indicate the per cent to total cost excluding land

Zone II

The total cost per hectare excluding land in wheat was observed to be Rs. 14006, Rs. 12662 and Rs. 11453 on small, medium and large farms, respectively (Table 1). The study reveals that the expenditure on human labour in absolute as well as in relative terms varied inversely, but that the expenditure on machine labour varied directly with the size of the farm. The study also reveals that use of fertilizer in relative terms varied directly with the farm size. The returns over total costs excluding land were found to be Rs. 16600, Rs. 19149 and Rs. 21765 per hectare on small, medium and large farms, respectively. The study reveals that the gross

Table 2: Regression coefficients of Cobb-Douglas type functions for wheat cultivation in different agro-climatic zones of Punjab, 2001-02

	Zone I			Zone II			Zone III			Punjab overall		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Intercept	0.727	1.152	1.274	0.354	0.217	-	1.693	0.197	2.046	0.278	0.577	0.500
Value of seed	0.852ns	0.684ns	1.914ns	3.111***	0.840ns	-	0.318ns	0.099ns	0.622ns	3.028***	0.584ns	0.174ns
Weedicide (Rs.)	4.030***	0.023ns	1.860ns	0.906ns	0.582ns	-	1.191ns	0.217ns	0.521ns	4.590***	1.498ns	1.442ns
Plant Protection Measures (Rs.)	0.063ns	3.822***	0.498ns	0.154ns	0.270ns	-	0.076ns	1.291ns	1.790ns	0.182ns	0.695ns	0.971ns
Nitrogen fertilizer (Rs.)	0.278ns	1.507ns	0.938ns	1.540ns	1.255ns	-	0.296ns	1.419ns	3.120ns	1.674*	0.523ns	1.869*
Phosphatic fertilizers (Rs.)	0.238ns	0.420ns	1.724ns	1.624ns	0.330ns	-	0.041ns	1.130ns	1.879ns	2.787***	1.693*	0.883ns
Total human labour (Rs.)	2.921**	1.694ns	1.508ns	0.801ns	2.623**	-	1.970*	1.969ns	3.991ns	2.590***	2.781***	0.934ns
Machine labour (Rs.)	0.423ns	0.353ns	.413ns	2.314**	0.427ns	-	1.219ns	1.954ns	0.234ns	1.319ns	2.028**	2.253**
Irrigation (No)	4.028***	0.491ns	0.951ns	1.458ns	0.819ns	-	1.841*	1.378ns	5.345ns	6.700***	2.753***	0.324ns
Operational holding (Ha)	0.025ns	1.167ns	0.539ns	1.182ns	0.566ns	-	0.624ns	0.167ns	3.212ns	1.837*	0.894ns	0.223ns
Education	0.850ns	1.095ns	0.583ns	0.153ns	0.135ns	-	1.707ns	1.641ns	3.907ns	1.557ns	2.012*	1.162ns
Interaction	1.147ns	1.061ns	0.152ns	0.378ns	0.577ns	-	0.345ns	0.694ns	2.573ns	0.549ns	1.435ns	0.381ns
R^2	0.928	0.9234	0.9973	0.7209	0.7206	-	0.5272	0.8656	0.997	0.6353	0.7219	0.1442

Note: ns denote non-significant at 10 per cent level of significance

***, **, * denote significant at 1,5 and 10 per cent level of significance

returns as well as returns over total costs excluding land in wheat varied directly with farm size.

Zone III

The total cost per hectare excluding land in wheat was observed to be Rs. 10247, Rs. 9796 and Rs. 9969 on small, medium and large farms, respectively (Table 1). The study reveals that the highest expenditure was incurred on machines on all categories of farms. The expenditure on human labour was more on small farms as compared to other categories of farms. The study also reveals that use of fertilizer in absolute terms varied directly with farm size. The returns over total costs excluding land were found to be Rs. 14995, Rs. 16110 and Rs. 17221 per hectare on small, medium and large farms, respectively. The gross returns as well as returns over total costs excluding land in wheat varied directly with farm size.

Punjab overall

The highest share of machine labour was found to be 31.08, 35.61 and 36.32 per cent of total costs excluding land respectively on small, medium and large farms respectively. The study concludes that the expenditure on machine and fertilizer in absolute as well as in relative terms varied directly with farm size, and that the gross returns as well as returns over total costs excluding land in wheat varied directly with farm size.

Determinant and Marginal Value Productivities

Zone I

From table 2 the value of R^2 (the co-efficient of multiple determination) came out to be 0.928, which indicates that about 93 per cent of variation in value of wheat yield was explained by the explanatory variables on small farms. The co-efficient of weedicides and human labour turned out to be 4.030 and 2.921, which indicates that with 1 per cent increase in expenditure on weedicides and human labour, the resultant value of yield increases by 4.03 and 2.92 per cent, respectively. This shows that expenditure on weedicides and human labour needs to be increased on small farms of zone I. The table also reveals that increased irrigation was directly related to the value yield of wheat. The marginal value productivity of seed, weedicide, plant protection, human labour and

Table 3: Marginal value productivity of inputs for wheat crop in different agro-climatic zones of Punjab, 2001-02

	Zone I			Zone II			Zone III			Punjab overall		
	Small farmer	Medium Farmer	Large Farmer	Small farmer	Medium Farmer	Large Farmer	Small farmer	Medium Farmer	Large Farmer	Small farmer	Medium Farmer	Large Farmer
Seed	5.47	-15.35	40.00	17.86	7.26	-	-16.35	10.07	11.58	12.30	4.58	2.84
Weedicide	54.87	10.71	-29.07	-6.69	8.39	-	38.98	8.06	-13.91	20.38	11.18	8.81
Plant Protection Measures	339.97	-	313.05	-	-	-	-733.99	-108.06	386.02	-408.30	250.09	118.46
Nitrogen Fertilizer	-20.50	18.30	-6.20	5.42	5.28	-	11.49	-10.30	-71.06	5.00	23.64	17.94
Phosphatic fertilizers	-9.79	11.64	16.28	-5.09	8.35	-	-3.20	-12.04	12.01	6.04	9.68	-2.73
Total human labour	4.36	4.51	-30.90	-2.66	2.04	-	1.28	7.67	38.89	0.85	2.13	1.92
Machine labour	-0.89	1.23	-1.35	2.45	0.97	-	1.92	11.55	-0.72	1.05	2.08	5.85
Irrigation	67.94.43	3127.18	4522.18	2305.11	2845.30	-	3238.87	4065.63	-9931.76	7854.62	6163.87	-788.02
Operational holding (Ha)	7587.75	12264.64	684.23	-22205.3	-	-	-5478.83	1414.18	3357.06	-20205.2	1082.17	1335.68

irrigation on small farms were found to be 5.47, 54.87, 339.97, 4.36 and 6794.43, which signifies that additional spending of Rs. 1 on these variables will increase the gross returns by Rs. 5.47, Rs. 54.87, Rs. 339.97, Rs. 4.36 and Rs. 6794.43 (Table 3).

Singh and Jain (1985) also clearly underline the scope for increasing agriculture production along with the nature of shifts in inputs and output max for different size categories of farms consequent upon the augmentation of basic crucial water input. The regression co-efficient of plant protection measures included in the study was found to be significant on medium farms. The table reveals that with a Rs. 1 increase in expenditure on plant protection measures, the resultant value of yield would increase by Rs. 3.82. The study also reveals that the regression co-efficients of all the explanatory variables turned out to be non-significant on large farms (table 2). The MVPs of weedicide, nitrogen, phosphatic fertilizer, human labour and irrigation on medium farms were found to be 10.71, 18.30, 11.64, 4.51 and 3127.18 signifying the additional spending on these variables will increase the gross returns by Rs. 10.71, Rs. 18.30, Rs. 11.64, Rs. 4.51 and Rs. 3127.18 respectively. The MVPs of seed, plant protection, phosphatic fertilizer, and irrigation on large farms were found to be 40.00, 313.05, 16.28, and 4522.18 signifying the additional spending on these variables will increase the gross returns by Rs. 40.00, Rs. 313.05, Rs. 16.28, and Rs. 3127.18 respectively (Table 3).

Zone II

The regression co-efficient of seed and machine labour turned out to be 3.111 and 2.314, which indicates that with a 1 per cent increase in expenditure on seed and machine labour, resultant value of yield would increase by 3.11 and 2.31 per cent respectively. This shows that expenditure on seed and machine labour need to be increased on small farms in zone II (Table 2). The marginal value productivity of seed, nitrogen, and machine labour were found to be 17.86, 5.42 and 2.45 respectively on small farms, which indicates the scope of additional use of these variables. The study reveals that an additional rupee on seed, nitrogen, and machine labour would increase the value productivity of wheat by Rs. 17.86, Rs.5.42 and Rs. 2.45 respectively (Table 3).

In the case of medium farmers the co-efficient of human labour turned out to be 2.623, which indicates that with 1 per cent increase in expenditure on human labour, the resultant value of yield would increase by 2.62 per cent (table 2). The study observed that an additional rupee on seed, weedicides, nitrogen and phosphatic fertilizer, and human labour would increase the value productivity of wheat by Rs. 7.26, Rs.8.39, Rs. 5.28, Rs. 8.35 and Rs. 2.04 respectively (table 3). The number of wheat cultivating large farms in the sample village was very small in this zone, therefore the regression analysis was not carried out due to the problem of

degree of freedom. But the sample farmers were included in the overall study.

Zone III

The regression co-efficient of irrigation turned out to be 1.841, which indicates that with a 1 per cent increase in irrigation, the resultant value of yield would increase by 1.84 per cent. This shows that irrigation needs to be increased on small farms. All coefficients are observed to be non-significant on medium and large farms (table 2). The marginal value productivity of irrigation was found to be 3238.87, 4065.63 and –9931.76 respectively, on small, medium and large farms. This shows the scope of additional use of these variables on small and medium farms, but a negative sign of coefficient shows over utilization of irrigation on large farms. The marginal value productivity of weedicide and nitrogen fertilizer were found to be 38.98 and 11.49 respectively on small farms, which shows the scope of additional use of these variables. The study reveals that an additional rupee on weedicides and nitrogen fertilizer would increase the value productivity of wheat by Rs. 38.98 and Rs. 11.49 respectively. In case of medium farms the study observed that an additional rupee spent on seed, weedicides, human labour and machine would increase the value productivity of wheat by Rs. 10.07, Rs.8.06, Rs. 7.67 and Rs. 11.55 respectively. Similarly in case of large farms the study observed that an additional rupee on seed, plant protection, phosphatic fertilizer and human labour would increase the value productivity of wheat by Rs. 11.58, Rs.386.02, Rs. 12.01 and Rs. 38.89 respectively (table 3).

Punjab Overall

The highly significant regression co-efficient of seed, weedicides, phosphorus and human labour came out to be 3.028, 4.590, 2.787 and 2.590 respectively which indicates that with a 1 per cent increase in expenditure, the resultant value of yield would increase by 3.03, 4.59, 2.79 and 2.59 per cent on small farms. The nitrogen fertilizer was also found to be significant at 10 per cent level of significance. The co-efficients of phosphorus fertilizer, human labour and machine labour on medium farms came out to be 1.693, 2.781 and 2.028. In case of large farms the nitrogen and machine labour has a direct relationship with value yield of wheat (table 2). The marginal value productivity analysis concludes that the scope of additional use of seed and weedicide for increasing value productivity varied inversely with the farm size. The marginal value productivity of plant protection measures, nitrogen and phosphorous fertilizer were found to be more on medium farms as compared to small and large categories of farms, showing more scope of additional use of these variables.

Reasons for economic losses

An attempt has been made to compare the potential and realized yields and hence estimate the yield gaps on different farm size categories. Yield gap I (gap between potential yield and average actual yield of farm) and yield gap II (gap between highest yield and average yield of crop attain in particular vicinity), has been estimated for this purpose.

A wide yield gaps existed in the wheat productivity between potential yield, highest yield and sample farms average yield. The magnitude of yield gap II was found to be more (i.e. 2641 kg,1543 kg and 2704 kg per hectare) on small farms of Zone I, II and III respectively as compared to medium and large farms. The higher yield gap II implies that greater amount of highest yield was left untapped on actual average yields. The highest estimated index of yield gap I was worked out to be 64 per cent on small farms of Zone I. The lowest estimated index of yield gap I was worked out to be 15 per cent on large farms of Zone II. The study reveals tremendous scope to improve the wheat production in the study area. The overall economic losses due to non-adoption of recommended technology was observed to be 2516 kg per hectare on small farms (Table 4). The zone-wise analysis shows that Zone II (Central Zone) observed better yield (4282 Kg, 4653 Kg and 5016 Kg per hectare on small, medium and large farms respectively) as compared to other zones. The major reason for such gaps as identified in the study are sowing of varieties of wheat in zone I that are not recommended, use of more than recommended seed rate, non-adoption of seed treatment, late sowing of wheat, limited application of nitrogenous and phosphatic fertilizer and greater deviation observed in application of weedicide.

Suggestions for input-use-efficiency enhancement in wheat cultivation

The study revealed that the gross returns as well as returns over total costs excluding land on large farms of zone II was more as compared to other zones i.e. zone I and III. Phosphatic fertilizer, human labour and irrigation were found to significant on both small and medium farms in the overall study. Seed, weedicide and nitrogen were also found to be significant on small farms. The marginal value productivity analysis concludes that the scope of additional use of seed, weedicide and irrigation for increasing value productivity varied inversely with farm size. The analysis brought out the need to increase the expenditure on these variables on small farms. The study

Table 4: Percentage yield realization of wheat in different agro-climatic regions of Punjab, 2001-02

	Zone I			Zone II			Zone III			Punjab overall		
	Small farmer	Medium Farmer	Large Farmer	Small farmer	Medium Farmer	Large Farmer	Small farmer	Medium Farmer	Large Farmer	Small farmer	Medium Farmer	Large Farmer
	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha
Potential Yield	5875	5875	5875	5875	5875	5875	5875	5875	5875	5875	5875	5875
Actual average yield	2109	2601	3075	4282	4653	5016	3661	3930	4158	3359	3724	4060
Highest Yield	3625	4750	4587	5125	5793	5825	3990	4860	5365	5125	5793	5825
Yield gap I	3766	3274	2800	1593	1222	859	2214	1945	1717	2516	2151	1815
Yield gap II	2641	2149	1675	1543	1172	809	2704	1435	1207	2466	2101	1765
Index of Yield Gap-I	0.64	0.56	0.48	0.27	0.21	0.15	0.38	0.33	0.29	0.43	0.37	0.31
Index of realized potential	0.36	0.44	0.52	0.73	0.79	0.85	0.62	0.67	0.71	0.57	0.63	0.69

observed that there is need to augment irrigation facilities on small farms in zone I.

The highest economic losses due to non-adoption of recommended technology was observed to be 2516 kg per hectare on small farms of Zone I (Sub-Montane zone). On the basis of above discussion it is suggested that:

- The wheat should be sown in recommended time.
- The application of nitrogen and phosphorous fertilizer should be applied at recommended level.
- The recommended dose of various brands of weedicides should be used.
- Over use of seed should be avoided.
- The seed should be treated with fungicide before sowing.
- The extension efforts should be more in zone I in terms of adoption of recommended varieties of wheat.

Reference

Singh, A.J. and Jain K.K. (1985) "Impact of Changing Levels of Irrigation Capacity On Different Size Categories of Farm in the Cotton Belt of Punjab", Journal of Research PAU. 22(4) : PP. 761–72. □

To give up the task of reforming society is to give up one's responsibility as a free man.

– Alan Paton

Feature

Input-output Relationship in Oyster Mushroom Production in Karnataka

Mamatha Girish, M.V. Srinivasa Gowda, M.R. Girish & Lalith Achoth

The application of single product translog profit function to farm-level data on Oyster mushroom production in Karnataka state has generated plausible results. Large growers showed a high degree of responsiveness to input demand and output supply in comparison to small and medium growers. Rising input price discouraged mushroom production while high output price encouraged use of more inputs. This has important implications for policy makers in view of the decreasing Oyster mushroom growers in Karnataka.

Mamatha Girish is research associate, M.V. Srinivasa Gowda is professor, M.R. Girish is research associate and Lalith Achoth is associate professor in the University of Agricultural Sciences, Bangalore.

Being rich in proteins, minerals and vitamins, mushrooms have been used as food from time immemorial. The nutritive value of mushrooms lies between meat and vegetables, with twice the protein content found in vegetables. Protein malnutrition particularly in infants, children, pregnant and lactating women, is one of the main nutritional problems in the Indian diet. Being low in fat and sugars, mushrooms are recommended for diabetic patients. Hence, the UN Food and Agriculture Organisation has recommended mushrooms as food supplementing proteins in developing countries where the population depends heavily on cereals for food.

Mushrooms are important not only from the nutrition point of view, but also for the disposal of agricultural waste. Mushrooms lack chlorophyll and hence they thrive on dead and decaying matter. Presently India produces 300 million tonnes of agricultural waste annually of which only a part is used as cattle feed. If mushrooms are grown on this waste, it will not only reduce environmental hazard by helping in the disposal of waste, but it will also convert this waste into useful protein-rich food.

The abundance of agricultural waste and the moderate climate prevailing throughout the year, are ideal for Oyster mushroom cultivation in Karnataka. Mushroom is a more profitable crop when compared to field crops and other horticultural crops in terms of income earned and the amount of cost and labour required for the production. The annual production of mushroom is around 50,000 tonnes in India of which 85 per cent is covered by button mushroom. Karnataka contributes 2.4 per cent (1200 t Oyster mushroom) of the total annual production of mushrooms in the country (Tewari, 2004). The other important mushrooms are Oyster (*Pleurotus spp.*), Black ear mushroom (*Auricularia polytricha*), Shiitake (*Lentinula edodes*) etc.

Mushroom production is an ideal occupation for landless labourers and small and marginal farmers due

to its indoor habitat, because it grows independently of sunlight, feeds on organic matter and requires no fertile soil. In addition to floor space, air space is also utilised profitably and this aspect of land utilisation is important in view of the declining land-man ratio and production of food crops. Hence, the present paper is an attempt to provide an insight into the input-output relationship in terms of demand for and supply of Oyster mushroom production to existing and potential entrepreneurs in Karnataka (Mamatha, 1998).

Methodology

Data required for the present study was collected from 105 Oyster mushroom growers spread over Bangalore, Belgaum, Dharwad, Mysore, and Shimoga districts in Karnataka state with the help of a pre-tested comprehensive schedule prepared for the purpose. The number of days required for raising one crop of Oyster mushroom in the cases of growers chosen for the study was found to be 35-45 days. The growers were post-classified into three categories based on the number of bags spawned per crop. The sample design of the growers is presented in Table 1.

Table 1: Classification of Oyster mushroom growers in Karnataka

Number of bags per crop	Category of growers	Number of farms
Up to 400 bags	Small growers	34 (32.38)
401 to 800 bags	Medium growers	32 (30.48)
Above 800 bags	Large growers	39 (37.14)
	Total	105 (100.00)

Note: Figures in the parentheses are percentages to total

The econometric applications of the new production theory based on the duality relationship between production functions and variable functions represents a major step forward toward generating appropriate emirical estimates of output supply and input demand functions. Application of the translog profit function to farm-level data allows a more disaggregated analysis of the farm production structure compared to the case of Cobb-Douglas formulation. The flexibility afforded by translog function permits measurement of the different impacts that exogenous variables have within and across the input demand and output supply functions (Sidhu and Baanante, 1981). In the present paper, the normalised restricted single product translog profit function is applied to the farm-level data on Oyster mushroom production in the Karnataka state.

The input demand and output supply elasticities so obtained are used to derive the relevant policy implications for the development of Oyster mushroom enterprises in the state. The input demand and output price responsiveness are especially important in view of the price policies that have been pursued by the Department of Horticulture, Government of Karnataka.

The input-output relationship in Oyster mushroom production in terms of unit prices was examined with the help of normalised restricted translog profit function. This model was fitted to each of the three Oyster mushroom grower categories and the input-demand and output-supply elasticities were estimated separately.

The general representation of the translog profit function is

$$\pi = G(p, q, z) \qquad ...(1)$$

where, $p = (P_1 ..... P_m)$ is a vector of output prices

$q = (Q_1 ..... Q_n)$ is a vector of input prices

and $z = (Z_1 ..... Z_r)$ is a vector of fixed factors

This function is assumed to satisfy regularity conditions (Lau, 1978) including positiveness, continuity, differentiability and convexity in P and Q.

Now, the general form of the normalized restricted translog profit function for a single output given by Christensen *et al.* (1973) and Diewert (1974) is as follows.

$$\ln \Pi^* = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln P_i^* + \tfrac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_{ij} \ln P_i^* \ln P_j^* + \sum_{i=1}^{n} \sum_{k=1}^{m} \beta_{ik} P_i^* \ln Z_k + \sum_{k=1}^{m} \beta_k \ln Z_k + \tfrac{1}{2} \sum_{k=1}^{m} \sum_{g=1}^{m} \delta_{kg} \ln Z_k \ln Z_g \qquad ...(2)$$

Where $\alpha_{ij} = \alpha_{ji}$ for all i, j and the function is homogenous of degree one in prices of all variable inputs and output. The definitions of the variables and the notation used are as follows:

Π^* is the restricted profit = (Total revenue minus total costs of variable inputs) normalized by P_y, the price of output. P_i^* is the price of variable input X_{ij}, normalised by P_y, the price of output.

Z_k is the k^{th} fixed factor.

$i = j = 1, 2, 3 ..... n$

$k = g = 1, 2, 3 ..... m$

ln is the natural logarithm and α_o, α_i, α_{ij}, β_k, β_{ik}, δ_{kg} are the parameters

$$S_i \equiv \frac{P_i^* X_i}{\Pi^*}$$

S_i is the ratio of variable expenditures for the i^{th} input relative to restricted profit and

$$S_y \equiv \frac{Y}{\Pi^*}$$

S_y is the ratio of output supply to normalised restricted profit. Note that S_y is also equivalent to the ratio of the total value of output to restricted profit.

Under the present situation, the single output considered is Oyster mushroom and the four variable inputs considered are straw, spawn, polythene bags and labour. These four variable inputs together constituted about 70 per cent of the total variable input costs for all the three categories of Oyster mushroom farms. The only fixed factor considered is the number of bags per crop which represent the ground space as well as air space utilised for Oyster mushroom production. Note that air space is utilised when the bags are kept on wooden stands.

The units of measurement used in the present study are:

Output	:	Rs. per kg of mushroom
Straw	:	Rs. per bag of straw weighing 1.5 to 2 kgs
Spawn	:	Rs. per bottle of spawn weighing 250 to 300 grams
Polythene bags	:	Rs. per bag
Labour	:	Rs. per labour hour

Here both hired labour and family labour are together considered as labour.

Differentiating the translog profit function (2) with respect to ln P_i and ln P_y gives a system of variable input/profit ratio functions and an output supply/profit function (Christensen *et al.*, 1973 and Diewert, 1974).

$$S_i = -\frac{P_i^* X_I}{\Pi^*} = \frac{\delta \ln \Pi^*}{\delta \ln P_i^*}$$

$$= \alpha_i + \sum_{j=1}^{n} \alpha_{ij} \ln P_j^* + \sum_{k=1}^{m} \beta_{ik} \ln Z_k$$

Profits and variable inputs are determined simultaneously. Under price-taking behaviour of the farms, the normalised input prices and quantities (levels of fixed factors) are considered to be the exogenous variables.

Once the parameter estimates of equations 2 and 3 are obtained, the elasticities of variable input-demands and output-supply with respect to all exogenous variables evaluated at averages of the S_i and at given levels of variable input prices (for the case of fixed factors) are linear transformations of the parameter estimates of the profit function.

Using 2 and 3, one can derive input-demand functions, output-supply functions and the corresponding elasticity formula.

The own-price elasticity of demand (η_{ii}) for the input X_i is given by

$$\eta_{ii} = \frac{\delta \ln \Pi^*}{\delta \ln P^*} = -S_i^* - 1 - \frac{\alpha_{ii}}{S_i^*} \qquad ...(4)$$

where S_i^* is the simple average of S_i

Similarly, the cross-price elasticity of demand (η_{ij}) for input i with respect to the price of the j^{th} input is obtained by

$$\eta_{ij} = -S_j^* - \frac{\alpha_{ij}}{S_i^*} \qquad ...(5)$$

where $i \neq j$

The elasticity of demand for input i ($_{iy}$) with respect to output, price P_y, is obtained by

$$\eta_{iy} = S_y + \sum_{j=1}^{n} \frac{\alpha_{ij}}{S_i^*} \qquad ...(6)$$

Now the output supply elasticities with respect to output price, prices of variable factors of production and the quantities of fixed factors evaluated at averages of the S_i and at given levels of exogenous variables, can be expressed as linear functions of the parameters of the restricted profit function.

$$\text{Since, } Y \doteq \Pi + \sum_{i=1}^{n} P_i X_i \qquad ...(7)$$

$$\ln Y = \ln \Pi + \ln \left(1 - \sum_{i=1}^{n} \frac{\delta \ln \Pi}{\delta \ln P_i}\right) \qquad ...(8)$$

The elasticity of supply (η_{yi}) with respect to the price of the i^{th} variable input is given by

Table 2: Restricted parameter estimates of the translog profit function of Oyster mushroom farms

Category of farms	Inter-cept	Prices of					Num-ber of bags
		Mushroom	Straw	Spawn	Polybags	Labour	
			Small Farms				
Mushroom ratio to profit	6.72	-1.99 (1.58)	0.25(0.20)	0.98 (0.43)	0.36 (0.34)	0.28 (0.33)	0.26 (1.01)
Straw ratio to profit	-0.21	0.25 (0.20)	-0.14 (0.04)	-0.09 (0.06)	-0.06 (0.05)	0.01 (0.05)	-0.15 (0.16)
Spawn ratio to profit	-2.19	0.98 (0.43)	-0.09 (0.06)	-0.34 (0.21)	-0.01 (0.10)	-0.06 (0.08)	-0.17 (0.22)
Poly bags ratio to profit	-0.22	0.36 (0.34)	-0.06 (0.05)	-0.01 (0.10)	-0.15 (0.11)	-0.06 (0.11)	-0.26 (0.28)
Labour ratio to profit	-3.04	0.28 (0.33)	0.01 (0.05)	-0.06 (0.08)	-0.06 (0.11)	-0.10 (0.13)	0.26 (0.50)
			Medium Farms				
Mushroom ratio to profit	24.22	-1.04 (0.43)	0.37 (0.10)	0.13 (0.14)	0.27 (0.09)	0.14 (0.19)	-2.87 (0.71)
Straw ratio to profit	-6.22	0.37 (0.10)	-0.20 (0.04)	-0.05 (0.03)	-0.04 (0.02)	-0.06 (0.05)	0.74 (0.22)
Spawn ratio to profit	-4.97	0.13 (0.14)	-0.50 (0.03)	-0.35 (0.09)	0.05 (0.05)	0.01 (0.06)	0.75 (0.20)
Poly bags ratio to profit	-3.24	0.27 (0.09)	-0.04 (0.02)	0.05 (0.05)	-0.14 (0.04)	-0.02 (0.04)	0.30 (0.12)
Labour ratio to profit	-7.24	0.14 (0.19)	-0.06 (0.05)	0.01 (0.06)	-0.02 (0.04)	-0.06 (0.11)	0.98 (0.38)
			Large Farms				
Mushroom ratio to profit	5.34	-0.50 (0.13)	0.11 (0.06)	0.32 (0.06)	0.10 (0.03)	0.01 (0.08)	-0.34 (0.26)
Straw ratio to profit	-0.66	0.11 (0.06)	-0.10 (0.12)	-0.15 (0.03)	0.01 (0.06)	0.10 (0.08)	0.09 (0.08)
Spawn ratio to profit	-2.60	0.32 (0.06)	-0.15 (0.03)	-0.07 (0.03)	-0.04 (0.02)	-0.07 (0.04)	0.43 (0.12)
Poly bags ratio to profit	-1.11	0.10 (0.03)	0.01 (0.06)	-0.04 (0.02)	0.09 (0.06)	-0.09 (0.04)	0.04 (0.04)
Labour ratio to profit	-0.87	-0.01 (0.08)	0.10 (0.08)	-0.07 (0.04)	-0.09 (0.04)	0.10 (0.09)	-0.22 (0.11)

$$\eta_{yi} = -S_i^* - \frac{\sum_{j=1}^{n} \gamma_{ji}}{\left(1 + \sum_{j=1}^{n} S_j^*\right)} \quad ...(9)$$

The own price elasticity of supply is given by (η_{yy}) where

$$\eta_{yy} = \frac{\delta \ln Y}{\delta \ln P_y} = \frac{\delta \ln \Pi}{\delta \ln P_y} + \frac{\delta \ln}{\delta \ln P_y} \left(1 - \sum_{i=1}^{n} \frac{\delta \ln \Pi}{\delta \ln P_y}\right) \quad ...(10)$$

$$\eta_{yy} = \sum_{i=1}^{n} S_i^* + \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_{ij}}{\left(1 + \sum_{j=1}^{n} S_j^*\right)} \quad ...(11)$$

Results and Discussion

Based on the hypothesis that Oyster mushroom growers maximise economic gains, the normalised profit function was fitted to each of the three categories of Oyster mushroom growers. The parameter estimates of the normalised restricted profit function with respect to mushroom farms are presented in Table 2.

The estimates of Oyster mushroom supply and variable input demand elasticities of straw, spawn, polythene bags and labour with respect to mushroom price, variable inputs prices and fixed input (number of bags per crop) are valuable results in themselves, as they can be applied readily to assess the impact of a variety of micro-policy actions, especially the price of spawn and mushroom which is fixed by the Department of Horticulture, Government of Karnataka. The parameters of the translog model do not have direct

economic interpretation but they can be used to calculate the demand and supply elasticities defined in equation 2 at the sample means of the data.

Table 3: Derived elasticity estimates of supply of and demand for variable inputs in Oyster mushroom farms

Outputs-/inputs	Prices of				
	Mush-room	Straw	Spawn	Polybags	Labour
Small Farms					
Mushroom supply	0.99	-0.18	0.01	-0.21	-0.64
Straw	1.81	-0.74	-0.04	-0.13	-0.80
Spawn	3.12	-0.03	-0.40	-0.32	-0.56
Polybags	1.68	-0.11	-0.34	-0.89	-0.58
Labour	2.34	-0.29	-0.27	-0.27	-1.61
Medium Farms					
Mushroom supply	0.48	-0.05	-0.18	-0.01	-0.31
Straw	0.40	-0.34	-0.02	0.02	-0.14
Spawn	1.48	-0.02	0.21	-0.34	-0.42
Polybags	0.16	0.04	-0.56	-0.20	-0.26
Labour	1.63	-0.09	-0.27	-0.10	-1.23
Large Farms					
Mushroom supply	1.92	-0.23	-0.19	-0.09	-0.40
Straw	1.76	-0.94	0.18	-0.15	-0.75
Spawn	1.20	0.15	-1.12	-0.02	-0.19
Polybags	1.44	0.32	-0.06	-1.83	0.31
Labour	2.17	-0.54	-0.17	0.10	-1.63

The various elasticities based on the parameter estimates are given in Table 3. The elasticities so obtained are functions of variable input ratios, variable input prices and levels of fixed inputs and the parameter estimates of the translog profit function in Table 2. The following observations were made based on these estimates.

First, the own-price input demand elasticities in respect of straw, spawn and polybags were less than one (in absolute value) in the cases of small and medium farms indicating inelasticity. This means, change in the price of these inputs leads to less than proportionate change in their demand. It is quite natural that rise in the price of any commodity leads to fall in its demand.

Out of the four inputs considered, the prices of straw, polybags and labour were dependent on their supply-demand balance. However, the price of spawn, the critical input in mushroom production, is decided by the State Department of Horticulture, Indian Institute of Horticultural Research (IIHR) and Universities Agricultural Sciences in the state, all of which have usually maintained a stable price at Rs. 5 per bottle.

The own-price input demand elasticities were around one in large farms indicating considerable price responsiveness. Increasing input price reduced the demand for the same in large farms. Mushroom growers being rational entrepreneurs, in order to combat falling returns, reduced the input use as their prices rose.

Interestingly, in the case of labour, the own-price elasticity was negative and greater than unity in all the three categories of mushroom farms (i.e., -1.61 for small, -1.23 for medium and -1.63 for large farms) implying substantial price responsiveness. The input demand for labour was found to be price-elastic *inter alia* as the wage rate rises, the demand for the hired labour would decrease in all the three farms resulting in fall in the output. It can be concluded that the growers could not afford to pay high wages with the output price remaining fixed. Hence, high input price had a significantly adverse effect on resource use and output supply in oyster farms in Karnataka.

Second, the own-price supply elasticities of mushroom being positive and nearer to one (0.99) in small farms and greater than one (1.92) in large farms suggest that mushroom price had a substantial positive impact on production. However, the own-price supply elasticity of mushroom was less than unity (0.48) among medium farmers. It must be emphasized here that the mushroom supply elasticity was estimated subject to the fixed number of bags spawned per crop. Hence, the measured mushroom supply response is due to reallocation of variable inputs in response to output changes that occurred in small and large farms.

In Karnataka, Oyster mushroom is marketed by Horticultural Produce Co-operative Marketing Society (HOPCOMS) and retailers (together accounting for 70 per cent of mushroom marketed). HOPCOMS is a co-operative society for fruits and vegetables run by the Department of Horticulture, Government of Karnataka. Any mushroom grower in the state can register with the society and sell the produce through it. In the present context retailers refer to the vendors at vegetable market places.

It is important to note here that the own-price mushroom supply elasticities observed on the farms have definite implication with respect to change in quantity supplied for a change in its price. Although, HOPCOMS is one of the main market intermediaries for Oyster

mushroom, it has imposed a ceiling at 30 Kgs per day per grower. The capacity of small growers being less than 30 Kgs per day (around 10-15 Kgs per day) increase the mushroom supply to HOPCOMS in response to its rise in price. With the production of large growers being more than 30 Kgs per day, they sold the excess quantity to other market intermediaries, viz., retailers, departmental stores, hotels etc., as they can afford to bear the handling and transportation costs.

In the case of Oyster mushroom, the grower incurred the packing and transportation cost in Karnataka. On the contrary, to small and large growers, the inelasticity of supply among medium growers indicates that they were unable to bear the marketing costs in order to sell through other market intermediaries. Hence they did not respond to change in mushroom price.

Third, the inputs viz., spawn, straw, polybags and labour in mushroom production are indispensable. Mushroom production would not be possible even if one of the resources is not used. This point is strengthened by the negative signs of the cross-price elasticities of input demand across all the three categories of farms. The elasticities indicate that the inputs are generally complements under the existing production technology. Increase in the price of a particular input would result in decreased use of all other inputs.

Fourth, the elasticity of mushroom supply with respect to input was negative and less than one (in absolute value) in the three types of farms, but their magnitude varied across inputs. Any rise in input price would mean high production costs and low returns that would reduce profits. Therefore, it can be concluded that rising input price would discourage mushroom production.

Fifth, in general, input demand with respect to output price was positive and greater than unity in all the three sizes of mushroom farms. This suggests that the input demand is responsive to mushroom price changes. This is an important consideration for policy makers in view of the decreasing number of Oyster mushroom growers in Karnataka state. Increase in mushroom price results in increased demand for inputs that in turn results in increase in the mushroom supply as well as the number of mushroom growers.

Conclusion

In the present study, the application of single product translog profit function to farm-level data on Oyster mushroom production in Karnataka state generate plausible results. The response of the growers to changes in input and output prices varied according to the farm size. Large growers showed a high degree of responsiveness in terms of own-price input demand and output supply in comparison with small and medium growers. However, the cross-price elasticities indicate that the inputs are generally complements under the existing production technology. Rising input price discouraged mushroom production while high output price encouraged use of more inputs. This has important implications for policy makers, especially the Department of Horticulture, Govt. of Karnataka (which determines the price of spawn and mushroom), in view of the decreasing Oyster mushroom growers in Karnataka.

References

Christensen, L.R., Jorgensen, D.W. and Lau, L.J., (1973), "Transcendental logarithmic production frontiers". Review of Economics and Statistics, 55: 28-45.

Diewert, W.E., (1974), "Applications of duality theory". In Frontiers of Quantitative Economics, edited by Intrilligator, M.D. and Kendrick, D., Amsterdam, North Holland Publishing Company.

Lau, L.J., (1978), "Applications of profit functions". In *Production Economics* – A Dual Approach to Theory and Applications, edited by Fuss, M. and McFadden, D., Amsterdam: North Holland Publishing Company.

Mamatha, B.G., (1998), "An economic analysis of Mushroom Production, Marketing and Exports: A study in Karnataka". Unpublished Ph.D. *Thesis*, Department of Agricultural Economics, University of Agricultural Sciences, Bangalore.

Sidhu, S.S. and Baanante, C.A., (1981), "Estimating farm-level input demand and wheat supply in the Indian Punjab using a translog profit function". American Agricultural Economics association, **63**(5):237-246.

Tewari, R.P., (2004), "Mushroom – Now in the limelight". In The Hindu Survey of Indian Agriculture 2004, pp 133-134.

□

The most violent element in society is ignorance.

– Emma Goldman

Book Reviews

Indian Economic Development and Business: Emerging Issues and Outlook, Editors: *Suresh Chand Aggarwal, Rashmi Agrawal and Rakesh Shahani,* published by New Century Publications, New Delhi, 2005, pp 295, price Rs.675 / US $ 60.

The edited volume under review has been published in honour of the founder of the business economics discipline in India, Professor Lallan Prasad on the occasion of his 66th birthday. It contains contributions from a cross-section of experts on India's economic policy and business environment.

The editors have divided this volume into four major parts. The six articles in the first part analyse the issues of liberalization, privatisation and globalisation. Three papers in part II discuss poverty, employment and social sectors. Seven papers in part III analyse business strategy and marketing techniques, while three articles in the fourth and last part of the volume deals with development with environmental protection.

One of the nineteen articles, *Interlinkages between Growth of Financial Sector and Economic Development in India*, by Ritu Ranjan provides an empirical analysis of the response of economic growth to financial development across various industry groups and sectors of the Indian economy in the post-bank nationalisation period of 1973-74 to 1999-2000. An important policy implication following from these empirical findings is that in the contemporary regime of economic and financial reforms being undertaken in India, the banking policy of the Reserve Bank of India should focus on the economic units and undertakings within the public sector as also the service industry by providing adequate and timely credit to tertiary activities like construction, trade, transport, personal and professional services etc.

Suresh Chand Aggarwal's paper on *Growth and Efficiency of Banks in India* has examined the growth and efficiency achieved by the Indian banking sector after the start of the reform process in the early nineties. The performance of the banking sector has been examined by considering parameters like non-performing assets, interest spread and capital adequacy to name a few. He finds that the efficiency and profitability of the PSBs have improved since the beginning of the reform process.

P.N. Varshney, in his paper *Impact of Softer Interest Rates Regime,* discusses the impact of soft loan regime on different sections of the Indian economy. The analysis reveals that while banks, large corporates and governments have been the beneficiaries of the softer interest rates regime, the general public, the savers, depositors, investors, and especially the fixed income-earners, have been the sufferers. According to him the households are the foundation of the financial system and should not be 'rewarded' with a negative rate of interest. He calls for a change in interest rate policy so as to link it with the inflation rate so that the interest of depositors could be safeguarded.

S.K. Singh in his paper on *Public Sector Enterprises in India and Privatisation* examines the aims, the problems and suggests the subsequent solution to these problems. He highlights the different government policies related to their privatisation and the progress of disinvestments so far.

Deepa Saran has analysed the impact of global economic integration, especially increased FDI flows on the taxing power of nations, which in turn could have an effect on their welfare spending, in the paper *FDI Flows and International Tax Competition: A Case Study of the US Economy*. Since no nation wants to be left behind in attracting FDI inflows, a "race-to-the-bottom" in tax rates starts between nations. This increased tax-competition adversely affects their tax revenues. As nations compete on the tax front to woo FDI investors, they also compete with each other on the basis of "laxity of their environmental and labour standards". There is empirical evidence for the argument that MNCs (multi-national corporations) invest more in nations with liberal labour and environmental laws. Based on the empirical study

of the US economy for the period 1985-2000, the author concludes that the anti-globalisation stance seems unwarranted.

Anita Kumari analyses domestic sales growth of Indian engineering industries, electrical and non-electrical machinery, in the pre-reform and post-reform periods in *Liberalization and Growth of Domestic Sales of Engineering Industry in India*. She has also done an analysis of the factors affecting domestic sales growth by estimating a regression function using panel data techniques of analysis. It was found that the domestic sales increased in both the periods but that the growth rate of domestic sales declined in the post-reform period as compared to the pre-reform period. Her analysis of the factors affecting domestic sales growth reveals that productivity growth was an important factor in generating domestic sales growth during both the periods. Profitability is also found to be important in generating domestic sales growth, while size did not relate to domestic sales. During the post-reform period, among technology variables, imported capital goods are found to be important in generating domestic sales growth. She finds that for this period, growth of domestic sales is inversely related to technology imports, research and development expenditure, and capital intensity.

M.P. Singh et al raises the issue of the effectiveness of different poverty alleviation programmes in India in the paper titled *Dimensions of Poverty in India*. In their view all the poverty programmes launched by the Government should be merged into two - one for rural poor and the other for urban poor, that should be aimed directly at employment generation and poverty removal, and directly benefit persons living below the poverty line. They recommend that at the later stage, coverage of the poverty programmes should also include shelter, drinking water, education, health care, social security, nutrition, and reform in the farm sector. They argue that co-operation of the Government officials, poor citizens and social workers is required for the proper implementation as well as evaluation of the programmes.

A.K. Gaur examines the pattern of inter-state expenditure of the social sector in *Inter-State Social Sector Expenditure in India: Need for Reforms*. Empirical results of the paper reveal a precarious trend in inter-state expenditure of states in total as well as in per capita terms, in the social sector, especially during the post-economic reform period (1992-2002). According to him this trend is detrimental to the development prospects of the Indian states in the long run. He suggests that, if the pace of quality of human life in Indian federation is to be accelerated then state expenditure on social sector must be enhanced in future.

Nissar and Naveen in their paper *Structure, Growth and Employment: An Analysis of Delhi's Tertiary Sector* make an attempt to look into the growth of the tertiary sector, its contribution to the gross state domestic product (GSDP) and employment in Delhi over the eighties and nineties. Based on the statistical analysis, they have examined whether the growth in the tertiary sector has led to significant employment generation in the tertiary sector and its impact on the distribution of the growth across different components of this sector.

C. Tisdell in his paper on *Economics of Business Learning* points out how in text books the coverage of business learning is limited to a consideration of increase in productivity or cost reductions and supply-side bias exists. In his review of these texts he finds that no attention has been given to the underlying sources of business learning or to phases of such learning. He discusses certain models, which make it easier to distinguish the effects of learning on productivity or costs, and scale economies. According to him lack of attention in managerial economics to learning about markets is seen as a grave shortcoming. He, therefore, suggests that more attention ought to be given to the alternative strategies available to business for learning and aspects of motivation and activation for learning should not be neglected. His second paper provides a review on *Linear Break-even Analysis* as typically outlined in textbooks on managerial economics. It is claimed that a major shortcoming of these expositions is their failure to demonstrate under what circumstances linear break-even analysis is relevant for the business and in what circumstances it is inapplicable.

J. Nakaya in his paper on *A Practical Approach to Business Ethics* argues that the "multi-layered stakeholder theory", should be very straightforward for managers to employ. To adopt it, no managers are required to have special knowledge about the study of ethics. They need simply ask themselves, for example, would you want to buy your company's products if you were its consumer? Would you want to be laid off in some situation if you were an employee? Or would you want to live next to your company's factory if you were a neighbour of the company? The answers to these questions give managers a clear and acceptable insight into dealing with such issues.

Rashmi Agrawal in her paper on *People, Technology and Outsourcing* identifies that business process outsourcing (BPO) has arrived at an appropriate time when Indian Government is facing the problem of employment crunch. She emphasizes that BPO has the

potential of becoming a leading source of employment generation for the educated unemployed youth of the country. It is evident from her analysis that the BPO industry like the IT industry is gradually becoming an attraction for MNCs. But she cautions that cost differentials, quality of service and motivated workforce would be the main determinants in the long run for India to retain its status of most preferred destination. Therefore, the BPO sector will have to move fast to reach the higher end of the value chain.

Rakesh Shahani discusses the issue of *Stock Market Volatility*, which has increased in recently. He points out that extreme volatility shakes the confidence of existing investors and prevents new investors from entering into markets. He analyses different tools, especially market stabilization. He also tries to answer the question whether it would be appropriate to follow the model of other nations and apply it to India too. The biggest problem, according to him is that Indian market is quite thin with very low number of those investors who have high propensity to trade. Thus experts feel that the long-term solution is to make the market wider and deeper.

The paper on *Futures Trading in India at the Crossroads* by J.B. Singh highlights how the globalisation and liberalisation of the Indian commodity market has opened agriculture to global opportunities and challenges. He points out that the space vacated by the gradual withdrawal of the State has to be filled up by the institutions and instruments, which help in the smooth and beneficial functioning of the markets. He emphasizes the role of one such instrument - 'futures trading' in futures market in the commodities, especially agricultural and derived commodities. He points out that such a market not only provides ample opportunities for effective management of price risks through 'hedging', but also assists in efficient discovery of prices, which can serve as 'reference' for trades in physical commodities in both internal and external markets. He also focuses on the obstacles that confront the futures trading in commodities and the measures, which can be taken in order to improve such trading.

S.K. Grover attempts to explore the changes that are occurring in the discipline of marketing through the evolutionary processes in his paper titled *From Marketing to Strategic Marketing in Business*. He stresses that in the end, market orientation is likely to succeed by focusing on the customer-competitor orientation. The resultant competitive advantage basis constructs the discussion of marketing from simple desired exchange relationships to the focus on strategic aspects of marketing, where marketing action is not an action in isolation but related to corporation and its source of competitive advantage. He points out that the role of marketing is limited, considering the benefits attained by strategic marketing for achieving longer-term mission, vision, goals and objectives.

V.K. Kaul in his paper *Innovation, Environment and Government Policy* highlights the impact of economic activity on the environment. He examines the role of the government in protecting the environment and promoting innovation in Canada and examines to what extent the experience of Canada can be used for developing countries. He points out how advanced countries like Canada have taken lead in devising policy for sustainable development and have also taken appropriate measures and policy decision to encourage innovation. He indicates that in the developing countries the situation is not encouraging at all. He suggests that the policies should have clear goals and flexible approaches, be helpful in seeding and spreading environmental innovations, and be useful in regulatory coordination.

Yamini Gupt discusses certain key environmental aspects of business that have taken the global community by storm in *Some Environmental Aspects of Global Business*. This paper focuses on environment-related trade barriers and global warning. She has also briefly discussed certain other issues like dumping of ozone depleting substances and transnational pollution. She finds that not all kinds of economic growth are good for the environment. At the same time, economic growth driven by technology that uses fewer natural inputs and reduces emissions is environment-friendly. This kind of growth requires economic and policy incentives that can steer development in a sustainable direction. She feels that global business or international trade can play a pivotal role in this process by diffusing environment-friendly technologies around the world, which would require countries to remove trade barriers on modern technologies and reduce the cost of investing in clean technologies and environmental management systems.

G. Tantrigama highlights the experience of tourism in *A Critical Assessment of the Operation of Tourism Businesses in Goa*. Tourism has been promoted for its financial and economic benefits. The effects of tourism on environmental resources, the host community, and socio-culture were considered to be of secondary importance. He points out that Governments and local authorities play a passive role, allowing market mechanisms to determine resource use and priorities, whereas private business enterprises take the leading role in deciding the nature and pattern of development. This leads to resource overuse and exceeds the capacity limits for the sake of financial and economic

gain. He mention how Calangute in Goa is a good example of how unmanaged and uncontrolled tourism can lead to a set of problems that will threaten the sustainability of benefits of tourism in the long run. He suggests that because of the presence of both positive and negative impacts, tourism is an activity that requires careful guidance and that the utilization of resources should be properly managed to meet the needs of tourists while minimizing the harmful effects.

As a whole this volume contains a number of scholarly contributions from a cross-section of experts on India's economic policy and business environment. The wide-ranging topics discussed in the volume provide an insight into the present state of the Indian economy and its future prospects.

K.P. Sunny
Dy. Director (ES)
National Productivity Council
New Delhi – 110 003

Communication for Gender Sensitization *by Manisha Pathak Shelat*, Concept Publishing Company, 2004, pp. 212, Rs 400.

Gender stereotypes are an inherent part of our social fabric, a fabric which consists of men and women alike. Often the media, rather than being used as a catalyst for social change, simply reinforces these stereotypes in its portrayal of women. To see only women promoting washing powders in advertisements, for example, is clearly stereotyping women as housewives and implying that housework is their domain.

In "Communication for Gender Sensitization," the outcome of the author's Ph.D thesis, a study of 145 adolescents was conducted. They were divided into two groups – one experimental and one control – to analyse the effect of the Value Discussion Model in terms of change according to certain valuables including attitude towards gender equality and value clarification. The author has tried to evaluate the effectiveness of two major components of the Value Discussion Model, namely dilemma and discussion.

At the outset the author sets the subject in its conceptual framework, by discussing the difference between sex and gender, and also focusing on the concept of conscientization conceived by Brazilian educationalist Paulo Friere. This is followed by a chapter on literature review, then a chapter on methodology, followed by an analysis of data and finally results and discussion.

Data has been collected using self-administered questionnaires and qualitative data was collected with the help of a detailed guide of the 24 null hypotheses, of which only four were rejected.

The sample groups found the value discussion approach interesting and useful in exploring gender issues. The author found the discussion model to be effective in overcoming existing gender stereotypes and value judgements with respect to gender equality among adolescents. The 16 dilemmas presented to the adolescents which are listed as an appendix, makes interesting reading. Both pre-discussion and post-discussion responses are detailed.

The author argues that the importance of the study cannot be judged merely from statistics, but that the ideas discussed amongst the students would have an impact later in their lives whenever a gender related value conflict arose. How far this speculation is true is difficult to judge, especially in the light of the impact of social conditioning upon adolescents.

The author's suggestion that the mass media should make efforts to expose adolescents to images that counterattack gender stereotypes is sound.

This book will interest researchers, educationists, organisations working for gender equality, and also the reader who is keen to understand the dynamics behind the existing gender inequality in a country where the Constitution guarantees equality between sexes.

Payal Kumar
MA, SOAS, London University
Media consultant

Capital Formation and Entrepreneurship In Indian Agriculture *by A Ghosh*, Concept Publishing Company, 2005, pp 132, Rs 300.

This book aims to find out the characteristics of the pattern of capital expenditure and capital formation in Indian agriculture. The major obstacles and difficulties which impede the process of change and modernization of capital structure in different parts of the country are discussed in relation to the micro and macro case study of the state of West Bengal. It analyses the results of a probe made into the official records of two leading banks operating in the study area, with a view to ascertaining the nature of the deposit and credit flow.

The review of contemporary literature gives a brief about the shortage or inadequate supply of capital resources required for the proper utilization of the

country's productive potential and also for the expansion of productive capacity to meet the increasing domestic as well as export needs.

The broad finding of the data gives trends of private capital expenditure and capital formation, and reveals that a substantial portion of the credit meets the household consumption needs. The main contention is of the diminishing influence of non-institutional agencies in the rural credit market and increasing preference of the farming community for institutional agencies, particularly the co-operatives, both in the country as a whole and also in different states.

The case study of the villages in west Bengal in the two districts of Bardhaman and South 24-Paraganas, have been reviewed. In view of inter-state variation of the characteristics of capital formation the results have been assumed as reflecting the nature of change in fixed capital structure in rural farm business for at least the similar areas of the country, where agriculture still remains in a developing stage.

The nature of capital expenditure and capital formation in both agricultural and non-agricultural households shows that households try to keep spending to an absolute minimum to keep the enterprises running. At least for the non-agricultural enterprises this observation can be made with more confidence. The idea of development and entrepreneurial initiative seems to be lacking everywhere. Whatever development initiatives are taken remain limited to richer households having a bigger size of land holding - either owned or processed.

The preferred source of credit for the cultivator households are co-operatives, commercial banks and the government, and there is disenchantment towards private non-institution agencies. Moneylenders are turned to most likely because of their long-standing economic liaison with the cultivator households and their practice of taking a risk to advance credit to those cultivator households who would otherwise be considered non-credit worthy by the institution agencies.

It is difficult to generalise why even among the richer section of the farming households the initiative to plough back savings to agriculture in the form of capital expenditure or capital formation is lacking. Apart from the lure of assured return there are other constraints that stand in the way of their disposing of savings towards the development of their own agriculture.

Taking the total amount of credit together purported to be advanced by different banks in different years, the flow of credit, both in Bardhaman and South 24-Paraganas, do not show an upward rise. Whereas over the specified years a steady decline of the amount is clearly visible in the case of South 24-Paragans, the amount of credit goes and again comes down in the case of Bradhaman.

Both for Bardhawan and South 24-Paraganas, the amount of credit allocation for agriculture is observed to be generally higher compared to that allocated respectively for small-scale industries and services.

Both the RBI and commercial banks must consider why the credit–deposit ratios fixed by different banks cannot be increased so more needy cultivators can avail of the credit-facilities provided for by the government. If the co-operative banks and other rural banks can afford to increase the ratio to a much high level, why cannot the commercial banks behave in a similar fashion.

The author has attempted to provide an insight into the capital formation and capital expenditure in Indian agriculture. However, most of the data is used from the All India Debt and Investment Survey, Reserve Bank of India, which is outdated (1971-72). Similarly, the state comparisons are made for 1961 and 1971, while they should have been made for recent years as well. Even for the case study of West Bengal the data has been used up to 1990 only.

This book provides an insight into the credit formation in different states of India and is likely to be useful for the students of agricultural economics and agriculture credit management, researchers of Indian agriculture and also development agencies.

Rajesh Sund
Asstt. Director
National Productivity Council
□

An investment in knowledge pays the best dividends.

— Benjamin Franklin

News & Notes

Productivity Data for Selected Asia-Pacific Countries

Table 1: Total Factor Productivity Growth (%) (Growth in Real GDP per unit of Labour and capital combined)

Countries	1993	2000	2002
Bangladesh	0.54	0.92	1.18
Taiwan	1.43	0.46	0.33
India	3.32	1.27	1.00
Indonesia	–	8.86	0.87
Japan	–0.23	0.83	0.54
Korea	0.02	6.58	4.89
Malaysia	3.40	3.90	1.74
Singapore	6.17	3.90	0.88
Thailand	0.83	–2.89	–

Table 2: Capital Productivity Growth in the Economy (%) (Growth in real GDP per unit of capital input)

Countries	1993	2000	2002
Bangladesh	–8.48	–4.68	–5.82
Taiwan	1.12	–2.84	–1.71
India	2.61	0.36	0.22
Indonesia	18.84	4.59	11.16
Iran	0.12	1.97	–
Japan	–2.42	1.75	0.64
Korea	–8.66	3.44	0.88
Malaysia	0.27	2.9	–0.21
Thailand	–0.49	5.21	4.91

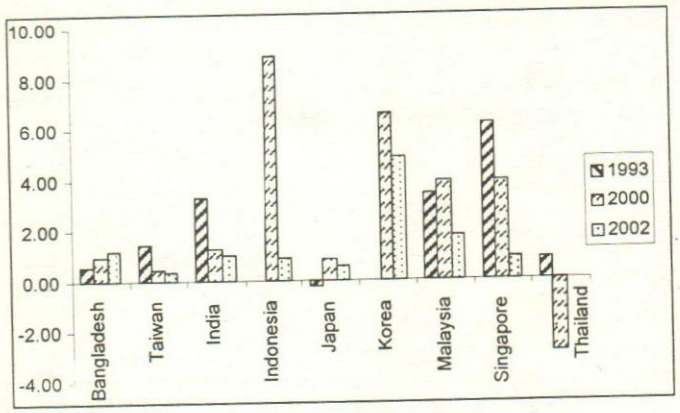


Fig . 1. Total Factor Productivity Growth (%)

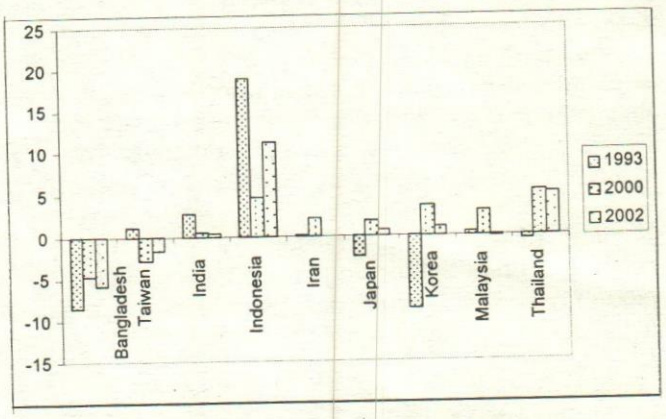


Fig. 2. Capital Productivity Growth in the Economy (%)

Table 3: Labour Productivity Growth in the Economy (%) (Growth in real GDP per person employed)

Countries	1993	2000	2002
Bangladesh	2.63	4.54	3.03
Taiwan	5.91	4.88	3.38
India	5.12	3.12	2.57
Indonesia	6.33	3.73	2.74
Japan	0.67	0.93	1.34
Korea	3.93	5.27	3.98
Malaysia	4.00	6.10	2.46
Nepal	5.65	0.59	0.72
Pakistan	–0.73	5.19	–0.55
Philippines	–0.76	11.86	0.64
Vietnam	5.60	4.67	4.70

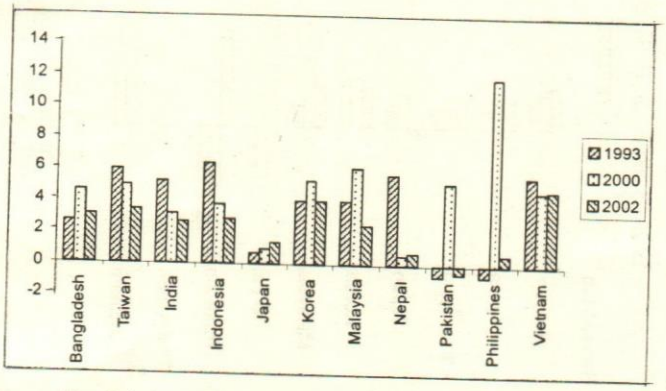


Fig. 3. Labour Productivity Growth in the Economy (%)

Table 4: Labour Productivity Growth in Agriculture Sector

Countries	1993	2000	2002
Bangladesh	1.38	6.28	–1.02
Taiwan	12.44	6.47	6.84
India	4.90	0.63	–4.50
Indonesia	6.94	–3.87	–0.23
Japan	0.06	5.48	7.22
Korea	–1.51	4.47	–0.49
Malaysia	3.20	0.52	1.11
Nepal	6.96	2.76	1.93
Pakistan	48.61	4.80	10.65
Philippines	–1.65	19.12	–0.89
Vietnam	1.39	3.58	–

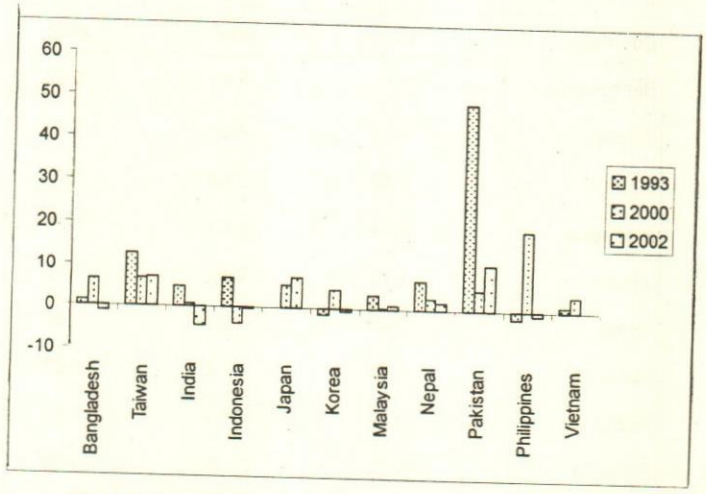


Fig. 4. Labour Productivity Growth in Agriculture Sector

Table 5: Labour Productivity Growth in Industry Sector

Countries	1993	2000	2002
Bangladesh	5.34	2.89	2.80
Taiwan	4.94	4.29	5.55
India	0.96	1.75	1.50
Indonesia	1.38	7.10	2.54
Japan	–2.58	0.34	1.77
Korea	5.89	5.84	1.44
Malaysia	4.49	8.86	2.67
Nepal	–5.80	–10.98	–7.60
Pakistan	2.44	–2.18	3.08
Philippines	2.16	10.87	4.68
Vietnam	9.84	6.48	–

Fig. 5. Labour Productivity Growth in Industry Sector

Table 6: Labour Productivity Growth in Service Sector

Countries	1993	2000	2002
Bangladesh	6.15	5.61	5.82
Taiwan	4.67	4.54	1.41
India	4.50	2.09	3.91
Indonesia	0.24	8.61	5.26
Japan	1.73	–0.88	1.76
Korea	–0.47	4.08	–0.40
Malaysia	6.64	3.82	6.87
Nepal	2.47	–0.04	0.04
Pakistan	–31.10	11.97	–9.58
Philippines	–0.90	4.39	0.43
Vietnam	4.11	0.53	–

Table 7: Labour Productivity Growth in Manufacturing

Countries	1993	2000	2002
Bangladesh	16.70	3.23	4.08
Taiwan	6.58	5.42	5.40
India	5.05	4.02	2.88
Indonesia	4.67	4.84	3.22
Japan	–0.95	5.44	2.74
Korea	6.54	7.77	6.97
Malaysia	7.00	11.05	3.32
Nepal	–0.87	–7.87	–6.16
Pakistan	15.33	–9.43	–16.18
Philippines	3.46	5.66	5.30
Vietnam	6.67	7.54	–

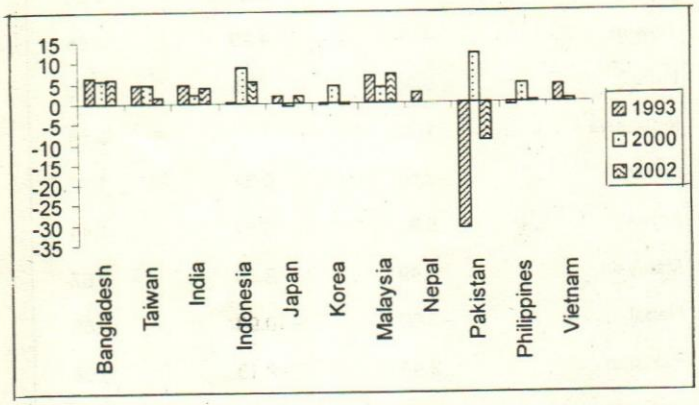


Fig. 6. Labour Productivity Growth in Service Sector

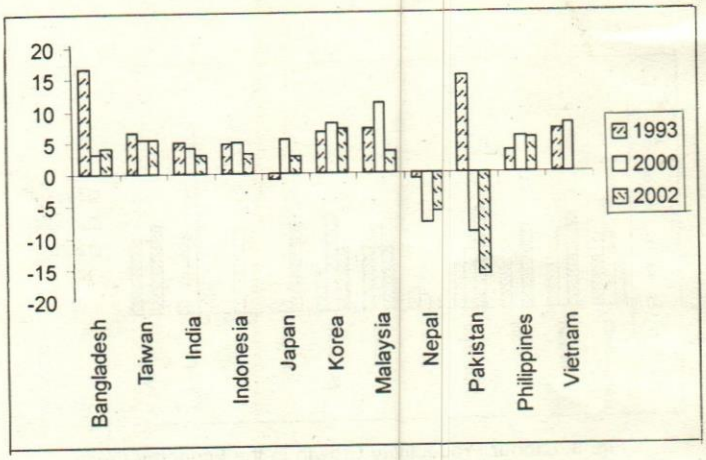


Fig. 7. Labour Productivity Growth in Manufacturing

Source: APO Asia-Pacific Productivity Data & Analysis, 2004

Compiled by
Rajesh Sund
Asstt. Director
Economic Services Group, NPC

Registered with Registrar of Newspapers

REGD. NO. 4757/59

Productivity

Announces

a

Special Issue
(April–June, 2005)

on

'Human Capital'