Focus

Technical Mastery: Basis for Strategic Manufacturing Management

L.U. Hendrickson & Nesa L'abbe Wu

The paper presents the open systems theories and the dynamic system planning (DSP) model that has the potential to bridge the gap between management of technology (MOT) and strategic manufacturing management. Initial research on the DSP model, that used data from about 170 companies, was broad in scope and did not focus significantly on the technical mastery issue. Because technical mastery – or the ability to produce competitively and productively – is essential to strategically manage manufacturing firms, this paper suggests a proven assessment technique to supplement the standard productivity and quality measures. This assessment technique, that offers a different perspective and unique insight into the obstacles to performance, addresses what strategies are being used to promote technical mastery and how effectively technical mastery is managed.

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The management of manufacturing has been influenced significantly by the ever increasing manufacturing changes due to technological progress. Therefore, research and policy-driven attention is increasingly being paid to the strategic management of new technology. Many view the effective management of technology as the key to improving the firm's productivity and thus restoring global competitiveness of many American industries. An obstacle to the accomplishment of this goal is the lack of a theoretical model that integrates technical and management issues into an overall strategic planning approach. Although several experts have cited the importance of viewing technology strategically (from the top of the corporation), the mainstream strategic management models still treat technolgy as generally subordinate to marketing and financial concerns – something you take care of after the main direction of the company is set.

There are exceptions. The Dynamic System Planning (DSP) Model has the potential to bridge the gap between the Management of Technology (MOT) and strategic management streams of research. The DSP model lists **technical mastery** – the ability to produce output of competitive quality and productivity (quantity of outputs made within a given period of time) – as one of seven core issues that a firm must manage strategically to assure its effectiveness. **Technology**, though a related term, as used here, more directly refers to the know-how, and equipment, and other tools used by the company. Technical mastery is achieved, in turn, by using both existing and new **technologies** (tools, knowledge systems) as well as by resolving other key management issues.

The DSP model, funded by a State of Michigan Research Excellence Fund Grant, used data from about 170 companies. Its results were recently published in a book (Hendrickson and Psarouthakis, 1992). This initial reautomobile companies spent six years bringing out a new type of vehicle, the Japanese were able to squeeze this time down to three or four years. The loss of market share and profits that resulted are widely known. Timeliness gives tremendous market advantage. The first company to meet customer demand for a new product can usually charge higher prices, at least initially, amortizing its research and development costs more quickly, generate stronger customer loyalty, making it more difficult for those who follow (National Research Council, 1987).

To remain competitive, companies today must shrink the interval of time between the first identification of a market need and the production of the finished product.

Strategic Management Research

In the last few decades, the field of strategic management has emerged as a separate identifiable discipline, with the majority of the research done in the last twenty years. A study led by Schoeffler, Buzzell, and Heany (1974), helped propel the credibility of the field by confirming strong linkages between strategic planning and profiitability, although their sample was based on large corporations.

Perhaps because it emerged out of the functional disciplines taught in business schools (marketing, finance, accounting, management) strategic management has borrowed heavily from each of them – especially marketing management. The marketing influence can be seen in the work of Michael Porter, still considered by many the most influential writer in the field of strategic management. Consider, for instance Porter's list of 12 "grand strategies," a central component of most of the popular strategic management texts now in use (Porter, 1985; Pearce & Robinson, 1991). Although Porter certainly touches on technical issues (including innovation and new product development) a close examination of the strategies reveals a heavy bias toward marketing and finance – either issues related to the company's product mix, or decisions related to buying, merging, or selling off portions of the corporation. Porter does include new product development and innovation as two of the 12 "grand" strategies – the "breakthrough" technology. But other strategies used by the Japanese in recent years – technical quality achieved through both technological investment and changes in organization design, manufacturing flexibility that has led to shorter time horizons for introducing new products – are largely ignored. In Japan, advanced manufacturing technology is linked to corporate strategy and long term investment (Currie, 1991). But in most American strategic management texts, the technical mastery issue fits into a "second" tier. That is, once the "grand" strategy is chosen, it is the work of each functional department head (including production and research and development) to design an implementation plan to support the "grand" strategy. Porter's grand strategies do not have any theoretical underpinnings. They are based essentially on scanning the activities of American corporations in the 1960s and 1970s. The results are by now rather obvious, given the record of the last five to ten years. Far from blaming the corporations alone, one must begin to ask whether the American business school treatment of strategic management – which for the past several decades has tended to overlook the importance of technology and technical mastery – should share in the blame.

Most prefer to consider technical mastery as a strategic issue coming from outside the discipline of strategic management. A number of economists, engineers and others *outside* the mainstream of the strategic management discipline stress the importance of technical issues (e.g. Abernathy et al, 1983, Cohen & Zysman, 1987; Adam & Swamidass, 1989; Steingraber, 1989).

On the positive side, new taxonomies of strategies are emerging that include the technical component (e.g. Morrison & Roth, 1992). However, a taxonomy is not a theory, and in the absence of one, there is the danger that in the future, CEOs may be blind-sided by some other issue equally significant to that of technical mastery. There is still a strong need for a coherent theoretical model that is broad-based and goes past the myopic view that has dominated past strategic management work.

Research reported in strategic management journals still leaves largely unquestioned whether the main-stream strategic management approach, as outlined in nearly all strategic management texts, is appropriate for smaller companies, including the small to medium manufacturer, at least some research confirms the importance of a formal planning model for large companies (Schoeffler, et al, 1974). But recent research on small firms is more mixed. At the very least, research raises doubts about the appropriateness of commonly taught strategic planning techniques in small companies. Several studies of small companies confirm the lack of formal business planning usage (Alpander, Carter, & Forsgren, 1990; Hendrickson & Psarouthakis, 1992; Hills & Welsch, 1988; Shrader, Mulford & Blackburn, 1989). Ohter research goes one step further, questioning where such models are necessary or even, perhaps counterproductive in obtaining company performance results (Hendrickson & Psarouthakis, 1992; Hills & Welsch, 1988). Such work suggests that whereas the CEO plays a key role in setting firm direction, formal strategic planning as taught in the business schools is simply not a part of the typical small company CEO repertoire.

The Dynamic System Planning Model

The Dynamic System Planning (DSP) Model (Hendrickson & Psarouthakis, 1992) is a strategic planning model that has its roots in open systems approaches to organization effectiveness (Katz & Kahn, 1989; Georgopoulos, 1986). According to all these models, organizations are viewed as open systems, pulling in energy from the environment, transforming inputs in a way that combats entropy (Georgopoulos, 1986).

The DSP model is based on an offshoot of this thinking, tested in over twenty years of research by Georgopoulos and colleagues (Georgopoulos, 1986). Rather than the more common approach taken by Katz and Kahn (1978) that splits organizations into subsystems (human, maintenance, etc.), Georgopoulos posits that any organization, no matter how small, faces certain enduring problems or issues.

The DSP model draws on Georgopoulos' work, as well as open systems theory concepts and more recent empirical research (Hendrickson & Psarouthakis, 1992). In all, seven management issues are identified that must be managed competently to assure the long term survival and growth of the firm. In addition, the DSP model is built on the premise that each of these issues fit into a clear overall vision and mission for the firm. These seven issues are as follows (see Figure 1):

- *Market strategy:* What is the company's market niche – who is it selling to and why are its customers buying?
- *Work flow:* How does the company assure the best flow of work? First, how does it divide work among everyone in – and, once divided – how does it assure that everyone's activities fit smoothly together?
- *Resource acquisition:* How does the company acquire the resources which it needs – money, people, supplies, information – to begin and/or continue to operate its business?
- *Employee Relations:* How can the company maintain adequate relations among employees – *esprit de corps,* employee motivation, s` that employees really contribute? How does it make sure that organization needs and individual needs are both met?
- *Resource allocation:* As you acquire the resources you need, how can you best make use of them? How should you spend your money, assign your staff or otherwise allocate raw materials, information, equipment and supplies?
- *Community and government relations:* Who else outside your firm can shut you down – or help you out? What groups or individuals should you be paying attention to other than your customers and suppliers?
- *Technical Mastery:* How do you maintain the highest productivity and quality? Do you have the needed technical knowhow? According to the model, each issue either directly or indirectly influences the effectiveness of the other six issues. Thus, technical mastery depends not only on the way it is managed, but also on how employee relations, work flow, resource allocation and acquisition, community and government relations and market strategy are handled. Technical mastery is included as a basic issue, not merely due to empirical or pragmatic reasons, but because it completes an essential part of the entropy-combatting input-transformation-output cycle: It represents the system's ability to transform inputs into products of a certain quality and at a certain level of production – whether these products are automobiles, microwave ovens or insurance documents.

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It is the ability of the organization to manage these seven issues that directly affects, in turn, the financial outcomes – short or long term. Unlike Porter's model then, technical mastery at any particular moment, may be equally or even more important than market strategy. Technical mastery and technology are related, but fundamentally different in an important aspect. Technology, by definition, is a means to an end: A tool actually used to

HP 1 — Professional hiring:
To what extent are people with specialized technical or professional training hired? (Mark the most appropriate answer).

[1] To a very great extent
[2] To a great extent
[3] To some extent
[4] To a small extent
[5] To a slight extent or not at all

Fig. 7: Sample Questions to Identify Hiring Practices (HP)

CC 1 — Work Climate:
For questions CC-1a to CC-1i, use the following answer choices. (Record in the spaces provided below):
[1] To a very great extent
[2] To a great extent
[3] To some extent
[4] To a small extent
[5] To a slight extent or not at all

To what extent do each of the following describe the work climate in your firm?
a. Spirit of cooperation
b. Climate of trust
c. Conflicts are dealt with head on.
d. Most productive people are highly respected by their peers.
e. If a problem comes up, people are confident the management will deal with it in the best possible manner.
f. New ideas are encouraged.
g. The most productive people are distrusted and ostracized by their peers.
h. You get further ahead if you don't rock the boat.
i. Spirit of competition and rivalry among groups within the firm.
(CC-1a to CC-1f are signs of a positive climate. CC-1g to CC-1i are usually seen as signs of a negative climate.)

CC 2 — Corporate values:
Does your CEO or president emphasize certain values that he or she feels are especially important to the success of the business? And what are they?

CC 3 — Value-sharing strategy:
Does your company have a particular way of sharing among company employees the values that the CEO feels are important to the success of the business? If so, what does your company do?

Fig. 8: Sample Questions to Identify Corporate Culture (CC)

Conclusions and Recommendations

Clearly, technical mastery is the basis for productive strategic manufacturing management. Because of the subjective nature of measuring technical mastery, an alternative approach to sophisticated quantitative models is imperative. The assessment approach as presented in this paper is a valuable instrument for measuring the technical mastery in manufacturing firms. The questions of Figure 2 through Figure 9 are only suggestive of the kinds of questions that might be asked. As this instrument is implemented, obvious areas will surface that may need to be more fully addressed and from this a universal model of technical mastery can emerge.

For questions TME-1 to TME-4, use the following answer choices. (Record in the spaces provided below):
[1] Very high: top 2% of the industry
[2] High: within top 10% (not 2%)
[3] Well above average: Top 25%
[4] Above average: Top one-third
[5] Average: about the middle
[6] Slightly below average: in the top two-thirds
[7] Well below average: Bottom One-Third

TME-1—Quality:
How would you rate the quality of the service, products or projects your carry out? (If you are in wholesale, consider the quality of customer services and accuracy in which orders are filled)

TME-2—Productivity:
How would you rate your firm's productivity, that is, its ability to complete projects or fill orders on schedule?

TME-3—Technical skills:
How would you rate the technical capability of your staff—their potential or skill, not necessarily how they actually perform?

TME-4—Technical Performance:
How would you rate the technical performance of your staff? How well they actually perform?

Fig. 9: Sample Questions for Measuring Technical Mastery Effectiveness (TME)

References

Abernathy, Willian J., Clark, K.B., & Kantrow, A.M., Industrial Renaissance: Producing a Competitive Future in America, New York: Basic Books, Inc., 1983.

Adam, E. & Swamidass, P., "Assessing Operation Management from a Strategic Perspective, Journal of Management, 15, June 1989.

Alpander, G.G., Carter, K.D., & Rosgren, R.A., "Managerial Issues and Problem Solving in the Formative Years", The Journal of Small Business Management, 28, 1990.

Bell, D., The Coming of Post-Industrial Society: A Venture in Social Forecasting., New York, Basic Books, 1973.

Brewer, Andrew W., "What about the organization?" Productivity and Inventory Management Review and APICS News, 9, Sept., 1989.

Burtless, Gary, Council on Competitiveness. Challenges, 8, No. 5 Sept., 1992.

Cleland, D., "Product Design Teams: The Simultaneous Engineering Perspective" Project Management Journal, 22, Dec. 1991.

Cohen, Stephen S., & Zysman, John, Manufacturing Matters: The Myth of the Post-Industrial Economy, New York: Basic Books, 1987.

Council on Competitiveness. Challenges, 8 No. 5, Sept., 1992.

Currie, W., "Managing Producing Technology in Japanese Industry–An Investigation into Eight Companies, part 2, Management Accounting, 69, July/Aug. 1991.

Datar, S. Kekre, S., Mukhopadyay, T., & Svaan, E., "Overloaded Overheads: Activity-Based Cost Analysis of Material handling in Cell Manufacturing," Journal of Operations Management, 10, Jan. 1991.

Ettlie, J.E., "What makes a Manufacturing Firm Innovative?" Academy of Management Executive, 4, Nov. 1990, A.

Georgopoulos, B.S., Organization Structure, Problem Solving and Effectiveness: A Comparative Study of Hospital Services, San Francisco: Jossey-Bass, 1986.

Harber, D.A., & Samson, D.A., "Japanese Management Practice: An Integrative Framework" International Journal of Technology Management, 4, 1989.

Hassard, J.S., & Procter, S.J., "Manufacturing Change: Introducing Cellular Production in Two British Factors," Personnel Review 20, 1991.

Hendrickson, L.U., & J. Psarouthakis, Managing the Growing Firm, Englewood Cliffs: Prentice-Hall, 1992.

Hills, G.E., & Welsch, H.P., High-Growth Entrepreneurial Ventures: A Content Analysis to identify Common Strategic Factors (unpublished working paper, 1988).

Hitomi, K., "Present Trends and Issues in Japanese Manufacturing and Management," Technovation, 12, April, 1992.

Hopkins, W.E., "Engineers as Strategic Managers: Performance Assessment," Journal of Management in Engineering, 7, April, 1991.

Katz, D., & Kahn, R.L., The Social Psychology of Organizations, 2nd ed., New York: John Wiley and Sons, 1978.

Manzi, J., "Productivity: Faith isn't enough," Computer World, 26, May, 1992.

Morrison, A.J. & Roth, K., "A Taxonomy of Business-Level Strategies in Global Industries, Strategic Management Journal, 13, Sept., 1992.

Mowshowitz, A., "On Managing Technological Change," Technovation 9, Dec. 1989.

National Research Council, "Management of Technology: The Hidden Competitive Advantage," National Science Foundation, National Academy Press, Washington, D.C., 1987. (unpublished report).

Pearce, J.A., & Robinson, R.B., Strategic Management: Formulation, Implementation, and Control, Homewood, Ill.,: Irwin, 1991, fourth edidtion.

Pennings, J.M., & F. Harianto, "The Diffusion of Technological Innovation in the Commerical Banking Industry, Strategic Management Journal, 13, 1992.

Port, O., "Back to Basics," Business Week, June 15, 1989.

Porter, M.E., Competitive Advantage, New York: The Free Press, 1985.

Rothwell, R., & Whiston, T.G., "Design, Innovation and Corporate Integration," R & D Management, 20, July 1990.

Schoeffler, S., Buzzell, R. D., & Heany, D.F. "Impact of Strategic Planning on Profit Performance, Harvard Business Review, March-April, 1974.

Sheridan, J.H., "The New Luddites?" Industry Week, 239, Feb. 19, 1990.

Shrader, C.B., Mulford, C.L., & Blackburn, V.L, "Strategic and operational planning, uncertainty, and performance in small firms," Journal of Small Business Management, 27, 1989.

Steingraber, The Seduction of Technology, Chief Executive, 49, Jan./Feb. 1989.

Swierczek, F.W., "The management of Technology: Human Resource and Organizational Issues" International Journal of Technology Management, 6, 1991.

Tyre, M.J., "Managing the Introduction of New Process Technology: International Differences in a Multi-Plant Network," Research Policy, 20, Feb. 1991.

Umble, M., & M.L. Srikanth, Synchronous Manufacturing: Principle for World-Class Excellence, Cincinnati: South-Western Publishing Co., 1990.

Van de Meer, J., & Calori, R., "Strategic Management in Technology-Intensive Industries," International Journal of Technology Management, 4, 1989.

Whiston, T.G., "Managerial and Organizational Integration Needs Arising out of Technical Change and UK Commercial Structure: Part I: Introduction and Overview," Technovation, 9, Nov. 1989.

Wilmot, R.W., "Computer Integrated Management—the Next Competitive Breakthrough", Long Range Planning, 21, Dec. 1988.

Yuen, E., "Human Resource Management in High and Medium Technology Companies, International Journal of Manpower, 12, 1991. □

Japanese firms is an important, but no longer a critical factor of success. All European car manufacturers are trying to reduce the gap between growth in turnover and number of employees (Figure 3). The aim, as expressed in Figure 4, is to reduce the break-even capacity, which at

Adding value and improving total quality

Every function, every position, every level of responsibility and every regional unit must make a contribution to:

The European Way to

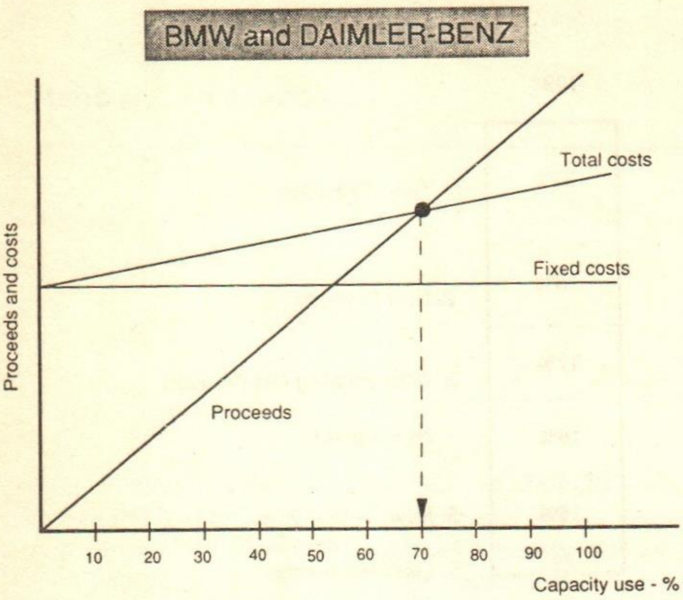


Fig. 4. Break-Even Capacity in the German automobile industry.

- increasing the value, and
- improving the total quality of the firm

The firm is to be understood as an "investment", the value of which is to be continuously increased and the quality of which is to be continuously improved. Adding value and improving the total quality of the firm means examining each strategic business unit in the value adding chain (Figure 5) and comparing it stage by stage with the performance of the strongest competitor or leading firm in the corresponding field. In this way, those functions, positions, levels of responsibility or regional units which make no contribution to adding value and which do not improve the total quality may be identified and reorganised or, in special cases, dispensed with. In the European industry there is actually a head-to-head run for restructuring the value adding chain in order to increase the value and improve the total quality of the firm.

Satisfying all "Stakeholders"

Lean management has obligations to all "stakeholders" who have identified their interests with that of the firm; it is important to satisfy customers, employees, shareholders, suppliers, society and member firms in joint ventures (Figure 6). The European approach does not privilegize shareholders, but, giving priority to customer satisfaction, tends to harmonize the legitimate interests of all major stakeholders. In addition, one must ascertain the criteria on the basis of which the individual stakeholders measure their degree of satisfaction. The customers, for example, are satisfied if the price is attractive, if service and quality are up to expectations and product durability is satisfactory; the employees are satisfied if salary level is appropriate, wages are fair, the working environment is satisfactory and there is a good team atmosphere. The individual criteria can be weighted according to their importance to the individual stakeholders

Elements of the Value Adding Chain	Weight Importance for Added Value	Worse / Better than the Competitors or Leading Refernce Firms					weighted score	Leading Competitor or Reference Firm	Actions for Improvement
		-2	-1	±0	+1	+2			
Recycling/Secondary Raw Materials	5			●			+10	We	No Action, observe A
Applied Research	8				●		+8	C	Simultaneous Engineering
Product/Process Development	10				●		+10	B	Simultaneous Engineering
Design	10					●	+20	We	No Action, observe B
Components/Sourcing	10	●					-20	D	Priority No.1: Outsourcing
Production	10		●				-10	D	Priority No.2: Redesign of Production System
Distribution/Logistics	8				●		+8	N	Learn from World Player N
Marketing	10					●	+20	We	No Action, observe A
Service/Use	10					●	+20	We	No Action, observe D
Dismantling/Waste/Management	7					●	+14	We	No Action, observe B
Quality of Management	10			●				P, Q	Learn from World Players P, Q
Human Resource Management	10			●				P, Q	Learn from World Players P, Q
Weighted Score							+80		

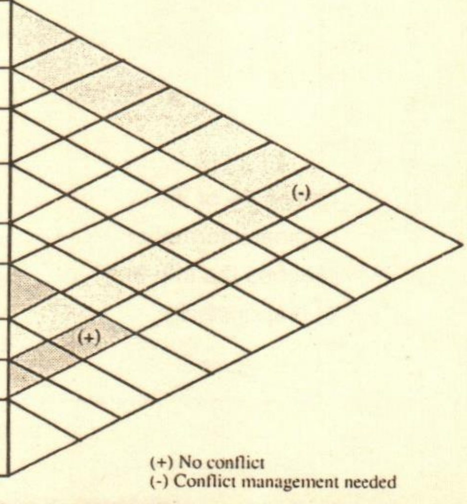
Fig. 5. The value adding chain (example).

STAKE-HOLDERS	SATISFACTION ATTRIBUTES	WEIGHT (Importance to stakeholders)	WORSE THAN COMPETITORS OR LEADING REFERENCE FIRMS -2	-1	±0	+1	BETTER +2	WEIGHTED SCORE	LEADING OR CLOSEST COMPETITOR OR REFERENCE FIRM	ACTIONS FOR IMPROVEMENT
Customers	Price	6			●			-	A, B, C	Target Costing
	Service	10	●					-20	A	Priority 1: Improve service organization
	Quality	10					●	+20	We, observe B	No action
	......									
Employees/ Management	Attractive Income	10				●		+10	We, observe C	No action
	Work Environment	9		●				-9	D	Investment in Social Facilities
	Quality of Management	10			●			-	A, C, D, E	Education programmes
	......									
Stakeholders	ROI	8	●					-16	D, E	Priority 2: Increase market share
	Dedicated Employees	10		●				-10	A, F	Priority 3: Improve incentive system
	Shareholder Value	10	●					-20	A	Priority 4: Total quality management
	......									
Community	Environmental protection	10					●	+20	We, observe D	No action
	Creating/Maintaining Jobs	8				●		+8	We, observe B	No action
	......									
Suppliers	Predictable Long Run Markets	10			●			-	A, B, D	Increase involvement of suppliers
	ROI	7			●			-	A, C, D	Improve incentive system
	......									
Partners in Strategic Alliances	Earn the Support of Partners	10				●		+10	We, observe C	No action
	Disclosure of information	6					●	+12	We, observe B	No action
	ROI	8				●		+8	We, observe A	No action
	......									
Weighted scores								+13		

Fig. 6. Determining stakeholder satisfaction: illustrative example.

and compared with the representative "Performance" of the strongest competitors, reference firms or one's own standards. Using this procedure, priorities can be set for a programme of improvement. Moreover, conflicts will become apparent, when, for example, shareholders desire a high ROI but this desire brings the firm into conflict with the need to find solutions for individual problem areas of customers. The decision of the top management will have implications for all concerned, whether ROI or the long term interests of the customers should be the management's strategic priority. (Figure 7) (See Ranganath Nayak et al (1992).

STAKE-HOLDER	SATISFACTION ATTRIBUTES	WEIGHT (importance to stakeholder)	WORSE THAN COMPETITORS -2	-1	±0	+1	BETTER +2	WEIGHTED SCORE
Customers	Highly customized product	10		●				-10
	Price	6			●			
	Speedy delivery ...	8					●	+16
Employees	Appreciative customers	10		●				-10
	Competitive wages	10				●		+10
	Work environment ...	9		●				-9
Owners	ROI	8	●					-16
	Dedicated employees	10		●				-10
	Protection against inflation ...	10	●					-20



(+) No conflict
(-) Conflict management needed

Fig. 7. Trade offs and conflict management required to satisfy stakeholders: illustrative example.

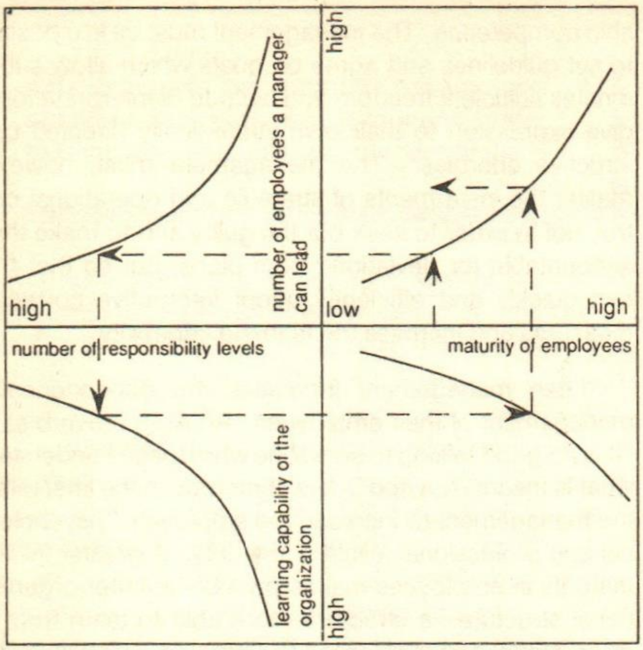


Fig. 10. The critical success factors.

stant pressure to design organizations which learn faster and are more innovative than the competition. Organizational learning is more than the sum of the learning abilities of an organization's members; it involves attitudes, knowledge, understanding, strategies and values, shared by the management and staff and inducing behaviour oriented towards the completion of a process. The experience and know-how of individual employees is lost when they undertake other tasks in the organization or leave the organization altogether. Organizational learning occurs when networks are established in the organization not only among those with know-how in the different functional and regional areas, but also between the different cultures within the organization. Within these networks, an exchange of information takes place, fostering management and employee behaviour directed towards core strategies and their associated processes; at the same time, the organization gains know-how which does not disappear when individual members leave. In a military situation, every subordinate learns to make decisions compatible with the aims of his superiors. In the same way, the management of a firm must conceive of processes which offer use and value to the stakeholders. At the same time, however, the management must understand the firm as a system and take the consequences of its decisions for the other parts of the organization into account. Lean management presents a challenge to managers. It challenges their ability to promote organizational learning at every level of responsibility in the firm and in each of the firm's regional units so that previously unforeseen opportunities can be exploited quickly and/or badly calculated risks can be avoided

At a time when product life cycles are becoming ever shorter, an organization's ability to learn becomes a key competitive advantage.

Lean management involves combining the central direction in the firm with operational freedom for those responsible for strategic business units, regional units, and functional areas. The greater the number of markets in which the firm operate, the more impossible it becomes to direct everything centrally and the more the direct influence of top management decreases. We may compare the present situation in the firm with the conduct of war in Napoleonic times. This comparison is informative because the Napoleonic times were also a time of transition. Napoleon himself admitted that his personal presence was necessary for victory. However, the theatre of war in which his armies fought soon became so large that he could not personally supervise all those areas where victory was crucial. From this situation and the experience gained from it emerged the necessity for a general staff which was uniformity and thoroughly trained. The existence of this staff meant that when the commander-in-chief could not be present in person, he possessed in the general staff, a body of generals which he could trust to understand his strategies and assist in their realisation.

In the world of business, the situation is similar. If men and women from the senior and middle management positions of the firm are able to take over the multiplicity of leadership positions in the regional and strategic business units of the firm, then a well-functioning instrument of management has been created. The leaders of these regional and strategic business units ensure that the formulation and implementation of strategy take place within the framework intended by the top managers. If senior and middle management positions are systematically reduced in modern firms then the ideal of a uniform training for those managers from whose ranks future entrepreneurial talent is to be recruited can no longer be realised. The more the firm distances itself from those important individuals who are imbued with the firm's corporate culture, the more difficult the decentralised management of strategic business units and regional units within the global framework of the corporate strategy of the firm becomes.

Lean management presupposes a move away from doing to the direction of serving. Serving is characterised by:

- The ability and preparedness to put oneself in the position of the stakeholders.
- Confidence in other people, but also in one's own ability to master new and unforeseen situations successfully.
- Open communication and active listening.
- An effort to make others successful, to create values, to satisfy stakeholders and to establish a listing channels of communication with others.
- Credibility, reliability, integrity and work on oneself.
- The ability to be always prepared
- Discipline, not in the form of slavish obedience, but as voluntary subordination in pursuit of common goals.
- The attempt to achieve detachment and to solve every problem form the perspective of senior management.

Figure 11 points out the shift towards a new balance between doing and serving. (Moser, 1991).

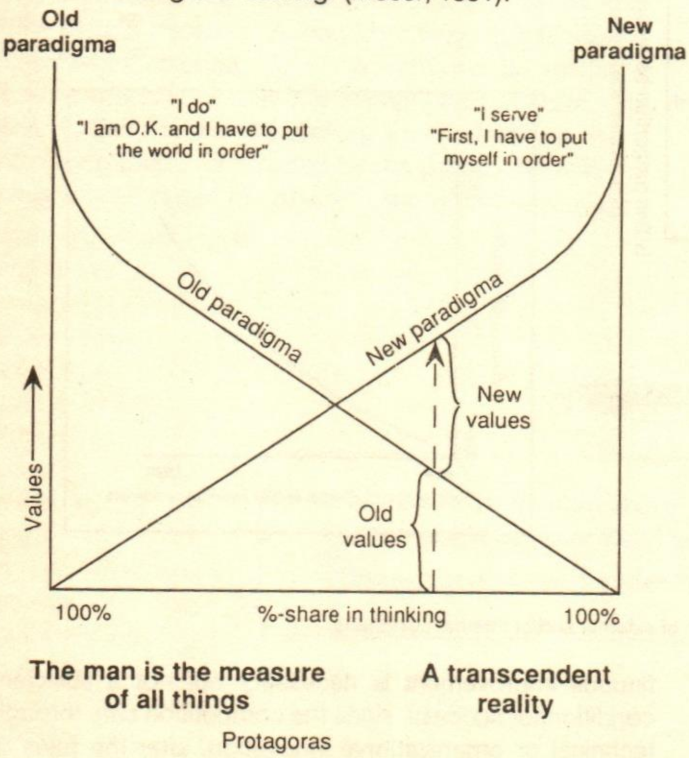


Fig. 11. The paradigma of doing and the paradigma of serving

> **Lean management presupposes a move away from doing to the direction of serving.**

A reconsideration of personal time management

Lean management places permanent time constraints on managers and presupposes a reconsideration of personal time management. With the help of the procedure outlined in Figure 12, every manager can divide up his or her free time on a percentage basis. Approximately 110 hours are available for:

- getting to grips with current management tasks.
- exploring future possibilities, changing and improving the firm's future and the manager's own personal future,
- family, and,
- health.

The figure shows how German middle managers allocate their time. In a turbulent environment, however, the time allocated for inventing the future, according to many managers, has to be dramatically increased. The question remains, however, is the present apportionment of time reasonable and how should time be managed in the future in the face of the opportunities and threats with which the firm is confronted? Figure 13 shows individual job security as a function of an individual's contribution for satisfying the needs and expectations of internal and/or external customers. The higher the percentage of time allocated for satisfying internal and/or external customers, the more an individual increases the probability of keeping his work under the conditions of lean management.

Lean management eliminates functions, roles, levels of responsibility and regional units which contribute no value and which do not lead to an improvement in the general quality of the firm. It involves developing a global understanding of processes in the minds of all managers and employees:

- How long does it take for our firm to develop and market a new product or service and how long does our fiercest need to do the same?
- How long does our firm need for a particular software development and how long does our fiercest competitor need?
- How does the quality of our products compare with that of competing products?

Time Based Competition: A New Competitive Weapon

L. Gelders, B. Andries & K.U. Leuven

Time has emerged as the critical dimension for improving competitiveness of both service and manufacturing companies. While reduction of throughput time on the shop floor is practised in many companies, there are other fields in which time has become a critical issue – new product development, engineering, administration and distribution. Several different management and engineering techniques exist to improve the responsiveness of a company. Early adopters report that actions modeled on JIT – simplified flows; waste reduction, reduced setup times and batch sizes – can also dramatically reduce global, not only production, lead-times. Firms able to achieve faster response times have reported growth rates over three times the industry average and double the profitability. Thus the payoff is market dominance. This paper focuses on these techniques and on the strategic implementation of making time the critical resource in the areas of new product development, engineering and production management.

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Lead-time reduction has a very strong impact on a company's competitiveness. Long lead-times in traditional companies require precise forecasts as guidelines for planning. When lead-times increase, forecast accuracy is reduced, inventories (Work in Process included) swell and safety stocks become indispensable. Wrong forecasts lengthen the lead-time because more unplanned jobs have to be executed. A strategy based on time breaks this vicious circle and enjoys the advantage of shorter lead-times and delivery times.

The evolution from a cost-based to a time-based company is not easy. Every aspect of the logistic chain must be reevaluated and streamlined. Three areas of the company are especially prone to time based strategy; new product development, production and distribution. Lead-time reduction in production is the essential condition to make time a critical resource. Next, distribution, or the link with the client, must be focused on time. Finally, product development must head in the same direction. Not all three areas are always as important. Department stores e.g. have to focus on distribution, while the electronics industry can take greatest advantage from rapid product development or improvement. In the automobile sector, all three aspects are of prime importance.

Three areas of the company are especially prone to time based strategy; new product development, production and distribution.

Time Based Competition (TBC) in Production

Time Based Competition is an opportunity to boost market penetration through short reaction times throughout the logistic chain. TBC is not a new technology but a philosophy that puts several elements of modern production control systems in a wider context.

> **Time Based Competition is an opportunity to boost market penetration through short reaction times throughout the logistic chain.**

Companies that have implemented the JIT-principles on the factory floor improved their production lead-times significantly. However, the gains were often lost by long delivery and/or development lead-times (e.g. in 1982 TOYOTA noticed that it took 15 to 26 days to accept an order, plan it and deliver it to the customer whereas the manufacturing took only 2 days producing the order; companies with design and production on order experienced similar problems in their design-phase).

The cornerstones of the implementation of time-based strategies in different departments of the factory are very similar to those used to introduce JIT to the manufacturing area. The idea of JIT was born in Japan, and was introduced first by TOYOTA. The need for JIT was a consequence of changes in the market structure: customers were asking for more variety and shorter delivery times. Hence JIT arose from the eternal conflict between marketing and manufacturing. To be customer-oriented these two activities need synchronized goals. For the customer and the marketing division, these goals can be translated into fast reaction times (short lead-times) and a wide range of products. It means flexibility and speed for the manufacturing division. The introduction of variety in this environment means more complex operations: more setups, more parts and more complex routings. Traditional views are based on the assumption that increased variety means decreased productivity and increased costs. The contrary has been proven by Japan's overall success and the successful implementation of JIT of Western companies.

The Search for Waste

The main aim of the implementation of JIT is the elimination of all waste (*muda*) in production and service. When no value is added to a product or service, the action is superfluous and time, money and throughput is wasted.

How to add value to a product? And how can we measure it? The most common definitions assume that value is added to a product when the product (or a part) undergoes a transformation (that is valuable for the customer, the production of waste is not value adding). However, in some cases, the transportation of a product can be value added. A distribution or a courier company for example adds value by bringing the product closer to the customer. In general, value is added to a product when a transformation process is perpetrated or when a product is brought closer to the customer. All operations which cannot be included in these two classes are wasteful and must be avoided or reduced to a minimum (e.g. inspections, queues, transport between workstations, drawings waiting to be finished in a CAD-system, orders waiting for release,...). The first step in the elimination of waste is identification. All the activities must be described and divided into a detailed time scheme. Every operation is classified as value added or non value added. Different methods can be used in this phase. Method and time-studies (MTM, MOST, Work Sampling) provide very detailed quantitative analyses of the activities. Qualitative methods like flowcharts and DFD (Data Flow Diagrams), are very useful to describe processes and procedures. In most processes non VAT-time will be responsible for more than 95 per cent of total lead-time.

Table 1 provides an overview of the different wasteful practices which are common to all manufacturing facilities.

Table 1: Wasteful practices

Inventories	Overproduction Batch Processing Warehouse Locations Individual Incentive Systems
Material Handling	Transportation Motion
Quality	Defects in Process Reduced Yield Inspection Quality Assurance
Floor Space	Function-Oriented Layout Raw Material Warehouse
Machine Utilization	Setup Maintenance Breakdown Reduced Speed
Non-Manufacturing Activities	Batch Information Processing

One of the most important reasons of low Value Added Time are large batches. Large batches automatically induce high Work in Process and long queues. Waste can only be eliminated when production runs are short are changeovers fast.

introduction can cause a 33 per cent decrease in net profits (Figure 2).

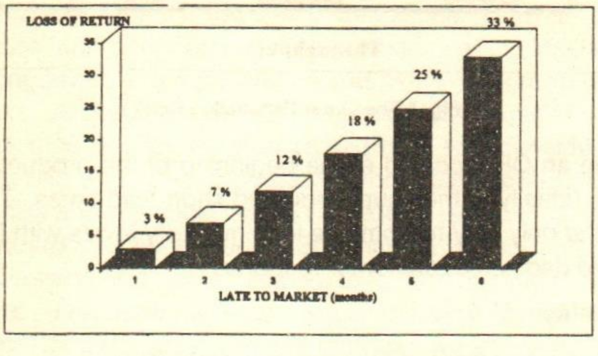

Fig. 2 Impact of late introduction

Research on fast product development is still in an embryonic stage compared to the well studied and documented JIT-principles of waste reduction and speed enhancement. The principles which lead to time compressed manufacturing processes are well known; but the same guide-lines for new product development seem to be non existent. A few concepts seem to crystallize.

- The necessity of an environment focused on change and innovation
- The use of information technology which provides the most performing tools to the innovation team.

The JIT-model is very attractive for new product development. First, the basic goals of JIT – the elimination of waste, simplicity, total quality and speed – are key attributes in all parts of the company. Second, the experience gained in production can easily be transposed to new product development. Third, JIT incarnates the *kaizen* principle of incremental and continuous improvement. (Imai, 1986)

Batch Size Reduction

In most Western conventional companies, the new product development and introduction program consists of consecutive or serial steps. In the very first stages, design-engineers are responsible for the conceptual design and the drawing of the plans. The plans and/or the prototype are delivered to the production engineers to prepare large scale production in a next stage. Then the department of planning and logistics prepare the bill of materials and resolve inventory and capacity problems. In the last phase, marketing and sales perform the market introduction. This phased approach of product design, development, manufacturing and marketing has important drawbacks like the very long product development cycle, 90 per cent of the budget costs being sunk before production engineers get involved in the process and the lack of market feasibility due to late involvement of marketing.

The major drawbacks of "consecutive engineering" may be resolved by concurrent engineering. Concurrent engineering is the simultaneous design of products and their engineering, manufacturing and marketing processes (Fig. 3). With this approach, teams attack all aspects of product development simultaneously. Information is released in incremental units, the batch size for information transfer from one design stage to the next is reduced to the smallest unit possible. What are the implications of small batch information processing for product development?

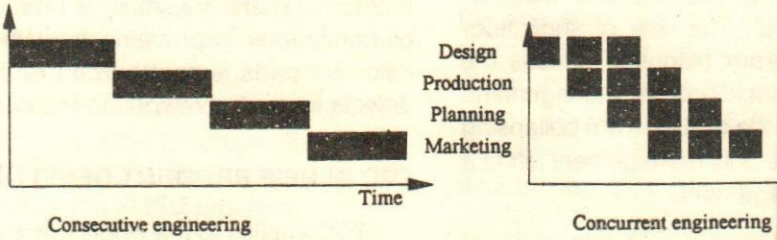

Fig. 3: New Product Development

The cost of change

In new product development catching mistakes early is very important, the later a change or revision is made the more expensive it is. During the initial phase the designer can make changes easily, often with little more than a few computer keystrokes. But later in the process, when the tooling for production has been made, changes become enormously expensive. The very same principles hold even before any tooling is made. In the later phases of the design process the different aspects are so interconnected that a small change rapidly becomes a nightmare. Business week has reported the cost of change for a major electrical product in each phase of its development (table 2).

In new product development catching mistakes early is very important, the later a change or revision is made the more expensive it is.

Table 2. The cost of change

Change during design	$ 1,000
Change during design testing	$ 10,000
Change during process planning	$100,000
Change during test production	$ 1,000,000
Change during final production	$ 10,000,0000

Parallel processing

To cut the time it takes to get a new product to market, one can perform many portions of the development process concurrently, that is in parallel. Instead of waiting until a phase of the NPD is complete before releasing information, partial information is sent downstream so that other members of the project team can begin their work. An obvious and supplementary advantage of this activity is design quality: early detection of problems. Basically there are three different ways to achieve concurrent engineering:

- *Overlap generations product*: Before design work on one generation is completed, design can be started on the next generation. This approach is the most effective to increase new product introduction rate.
- *Overlap phases of product design*: This is the most common and most widely spread approach of concurrent engineering: overlap former successive phases as overall design, detailed design, testing, manufacturing start-up and market analysis. This approach is the most effective way to save time in NPD, to increase design quality and hence to reduce costs.
- *Overlap steps of a phase*: Within one phase many of the steps can be done concurrently. This approach is the easiest to implement when starting a concurrent engineering program, but maybe the most overlooked. Companies which make their engineering, marketing and design department work together often fail to grasp the opportunity to make them work concurrently within one department.

However small batch information processing and concurrent engineering are not easy to implement and are accompanied with serious risks. Releasing partial information increases the likelihood of erroneous information sent downstream. Flexibility of the team workers is very important because they will have to work with incomplete information. People from different departments will have to overcome their reluctance of working together and to release incomplete information to critical eyes. Modern information technology and severe procedures must be introduced to prevent people to work with outdated information. It may take two full product development cycles to realize most of the benefits associated with concurrent engineering. When companies grow, lead-times tend to increase. This well known association in manufacturing can also be applied in NPD. Two major obstacles for the accomplishment of concurrent engineering in big companies are departmentalization and inappropriate performance measurement systems.

Departmentalization

When an organization grows, it becomes necessary to subdivide it in more or less independent departments. Usually this division is performed on the basis of functionality or product/market combinations. The main purpose is to increase productivity and efficiency, but there are major drawbacks to departmentalization. Members of the functional units develop values consistent with their unit. For example, the marketing department will attach great value to a unique product design while accountancy pays more attention to the cost structure of the product and production to its manufacturability. Departments may also vary according to their time focus. Marketing wants a product to reach the market as soon as possible while design begs for more time to ensure design quality. Based on their own perception of values and time focus, departments develop their own goals and priorities which may or may not be consistent with the overall strategic plans of the company. The bigger the company the bigger the divergence between local and global strategic issues. Communication between departments becomes very difficult, internal barriers are rising, response time lengthens and bottlenecks appear. It is therefore important to communicate the company's strategic vision to the different departments. The only way of doing this is to implement a performance measurement system which measures overall strategic goals.

Performance measurement systems

Many companies have performance measurement systems based on the individual performance of the departments (e.g. annual turnover, machine utilization rate, scrap percentage etc) instead of overall contribution. When departments are evaluated on the basis of perforproblems which must be solved in accordance to the *kaizen*-philosophy of incremental and continuous improvements. The areas prone to improvement are information flow, layout, quality and supplier relationship.

Information flow and layout

In most of the companies, new product development is organized as a job-shop. Design is done in one area, drawings are then transmitted in batch to the next department in the pipeline (engineering) and so on. With the introduction of concurrent engineering and cross-functional teams, people from different departments must be put together and work together simultaneously. This means that the layout must be reevaluated for every project in a process of ongoing improvement.

Quality

Introducing quality in manufacturing means "Do it right the first time". For new product development this principle can be translated into "Do the early part right". i.e. do the up front work thoroughly even at the price of lengthening that phase, because correcting an error or omission in a later phase can be very expensive. Many accounting people and budget cutters will likely denigrade an approach that calls for thorough initial planning. This may say that the best time to save money is early in the project because that leaves a lot of time to revise things later ("We can always produce a few more" in large batch manufacturing). That is completely incorrect however. It is much more cost-efficient to spend the money up-front to do the job right. In a process of continuous improvement, it is of prime importance to learn from the mistakes of former projects and to create an environment which encourages people to execute the initial phases properly.

Introducing quality in manufacturing means "Do it right the first time".

Supplier relationship

Suppliers play a crucial supporting role in reducing global new product development time. First, they must develop and deliver parts on time and second, to speed up the process, they have to release early and incomplete information (small batch information processing). It is therefore very important to build up long term cooperative relationships with suppliers (co-makership and co-design).

Time Based Performance Measurement

Prior to the implementation of a technique or technology it is important to know to what extent the actual situation copes with the strategic issues of the company, and how future changes will be evaluated (you get what you measure). Changes will be measured by means of performance indicators. If no performance measurement system is available, its implementation requires absolute priority. Heading on targets is impossible without measurement system.

TBC calls for fundamental changes in organization: time based goals must be introduced and others must be discarded. This implicates the introduction of a time based measurement and compensation system. Time performance must be measured instead of costs or turnover. Costs provide an accurate idea of financial results but they fail to provide efficient indicators for (manufacturing) processes and activities. Moreover cost-based performance measurement systems have often led to sub-optimality and island mentality. The time based measurement framework can be divided in two major subsystems: reactive and proactive systems.

Reactive systems

The function of reactive systems is control. They monitor the overall actual outcome, results of operations versus preset targets, plans and goals and trigger a corrective action when a deviation from preset targets is measured or expected. Due to their focus on results, however, control measures do not provide a specific clue for process improvement. Examples of time based reactive measures are given in table 3.

Table 3. Reactive performance measures

Production	Changeover times, batch-sizes, lead-times, inventory turnover,...
Product development	Time from idea to market, number of engineering changes, information batch-size, new product introduction rate, percentage first to market,...
Customer service	Cycle times, response times, number of complaints, due date performance,...

Proactive systems

Improving the process is the issue addressed in the proactive part of the measurement framework. It is called proactive because it tries to keep the process ahead of present and future needs, based on strategy, instead of only chasing present targets. Specifically, the proactive system provides a structured, formal process of cycle time reduction. It continuously identified time compression opportunities in the value added chain by means of diagnostic measures.

Two specific measures are used:

- the lead-time
- the ratio lead-time/value added time.

For both measures, a profile for the whole pipeline is established, i.e. both measures are tracked for each phase in the pipeline. The lead-time measure is important because it shows where in the process - in absolute terms – the largest amount of time is consumed. The ratio lead-time/value added time shows where in the pipeline relatively the largest amount of time is wasted. The goal is to reduce waste and hence to minimize the ratio (minimum = 1). But is it possible to eliminate waste totally? Of course not. Products have to be moved from one workstation to the other, there will always be queuing in front of workstations (to assure full capacity utilization). Besides is non-VAT always *non*-VAT? When a customer places an order one month in advance, is the waiting time before planning non-VAT? On the other hand is VAT always 100 per cent value added? What about a machine running at 80 per cent of its nominal capacity? It is very important to agree clearly on definitions of lead-time and VAT before the implementation of measurement systems.

Conclusions

Production control techniques have widely gained in interest during the last few years. JiT, pull systems, setup time improvement and manufacturing lead time reduction are considered competitive weapons by many companies. The most important reason for this evolution lies in Japan's economical success in the last decade. Recently the competitive war has acquired a new dimension. Time has emerged as the overall critical success factor. Time based competitors are conquering the market. Faster product development, manufacturing lead times and distribution, all the aspects of the logistic chain have become focused on time. The payoff is increased growth rate, higher profitability and market share. To fully enjoy the strategic advantages of time production control techniques must be extended to all the areas of the organization.

References

Blackburn, J.D., *Time-Based Competition - The Next Battle Ground in American Manufacturing*, Business One Irvin, Homewood, Illinois, 1991.

Bockerstette, J.A., SHELL, R.L, *Time Based Manufacturing*, Mc- Graw Hill, 1993.

Clark, K.B., Chew, B. & FUJIMOTO, T. Product Development in the World Auto Industry". *Brookings Papers on Economic Activity*, 3, 1987.

Gelders, L. "Shop floor Performance Management,", *Logistics Information Management*, Vol. 3, no. 1, 1990.

Imai, M., *KAIZEN: The Key to Japanese Success*, McGraw HIll (New York), 1986.

Mckinsey & CO., *Triad Power: The Coming Shape of Global Competition*, Flammarion, Paris, 1985.

Schonberger, R.J. *Japanese Manufacturing*, Free Press New York, 1982.

Shingo, S. *A Revolution in Manufacturing The SMED System*. Productivity Press Cambridge, 1985.

Stalk, G., *Competing Against Time: How Time Based Competition is Reshaping Global Markets*, Free Press, New York, 1990.

Womack, J.P., JONES, D.T. & ROOS, D. *The Machine that Changed the World*, Macmillan Publishing Company, New York, 1991. □

lion yen; (about 1.2 billion U.S. dollars) proposed by Japan's Ministry of International Trade and Industry (MITI). This project is intended to build a "Factory of the Future" based on the intelligent machines and expert systems through joint research and development by Japan, the United States and the EC. The advanced manufacturing technologies will be a worldwide common asset and so may be transferred to other developing countries.

Procedural Aspect (Information Flow)

The flow of information which play a main role in manufacturing systems consists of five stages, as shown in Fig. 4 (Hitomi, 1975).

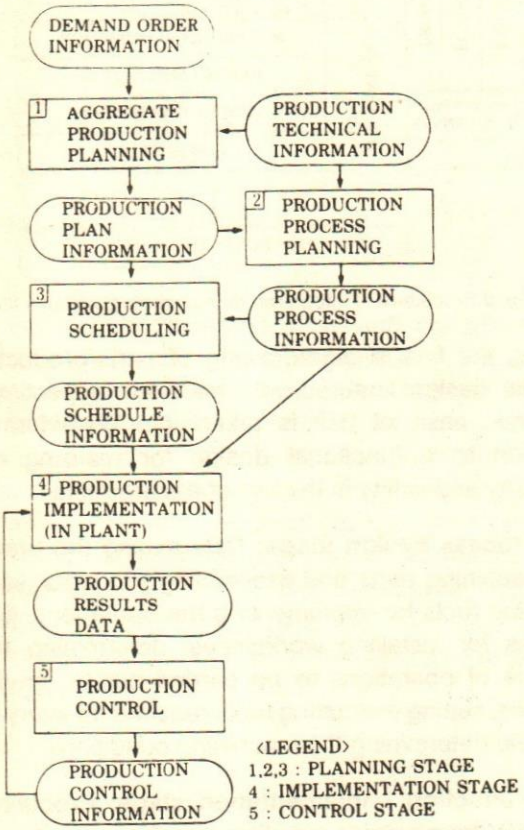

Fig. 4 Flow of information in manufacturing systems.

Aggregate production planning: Macro decision-making function for determining the types and quantities of products to be manufactured for the specified period of time.

Production process planning: Procedure for converting raw materials into finished products – a decision-making function related to the flow of materials, including product design and plant layout.

Production scheduling: Micro decision-making function related to time schedule for jobs.

Production implementation: Function for executing actual manufacturing operations in workshops.

Production control: Function for monitoring the progress of production and modifying the production plan which deviates from the designated standards established in the planning stage.

Of these five stages of management cycle, the production process planning handles the "technological information flow" and the aggregate production planning, production scheduling, and production control form the "managerial information flow". From this standpoint, manufacturing systems primarily include the following three different functions (Hitomi, 1991a):

- **Production,** which relates to the flow of materials.
- **Design,** which relates to the flow of technological information concerning the design of factory, processes and products.
- **Management,** which relates to the flow of managerial information concerning production planning, scheduling and control.

The five steps are 'operational' meaning that the activities are decided and performed inside the firm. At a higher level is the 'strategic' planning function, which is concerned with strategic issues between the firm and its environment (market, competitors, society, etc.), such as long-range planning, profit planning, pricing of the products to be sold, etc. These two phases – strategic and operational – are fundamental to the effective performance of the firm (Hitomi, 1975, Huebner and Hoefer 1984).

Decision Problems in Aggregate Production Planning

Optimal Product Mix. This determines the proper combination of the kinds of items to be produced with the existing production capacity. If there is insufficient capacity to produce the entire amount of products demanded, such a demand cannot be sufficiently fulfilled. In such a case, the optimal product mix (optimal kinds of products and their production quantities) should be properly selected. Some of the policies to solve this problem are: to maximize the total profit obtained by production under the capacity constraint; to maximize the total amount of products ordered even at the sacrifice of profit gained; etc. (Hitomi, 1976).

Requirements Analysis: This determines the quantity to be produced for every product under consideration in a specific period. Quantitative techniques such as mathematical programming, especially linear programming, quadratic decision analysis, etc. assist decision-making for solving this problem (Hitomi, 1972). MRP (Material Requirements Planning) plays an essential role in this field (Orlickly, 1975).

Lot-size analysis: In intermittent (or lot or batch) production, the demand rate is small compared to the possible production rate, and a product is manufactured periodically in a quantity which will just satisfy the demand for a specified period. In such a case, the production decision (economic lot size and optimal production cycle) is usually made to minimize the total production costs, which are taken as the sum of setup cost, manufacturing cost, and inventory cost (King, 1975). Recent trend is to meet market needs for a variety of products. Only one-piece (one-of-a-kind) production is also performed (Hirsch et al., 1992), especially in Japan, though this type of production requires no optimization since very strict conditions should hold for just one piece as the economic lot size (Hitomi, 1990b).

Production Smoothing: This evens out the level of production and adapts to the fluctuation of demands from the market, thus resulting in high utilization of production facilities. Management policies for this purpose are: time adaptation, inventory adaptation, intensive adaptation, quantitative adaptation, and subcontract adaptation (Gutenberg, 1955).

Decision Problems in Production Process Planning

Process Planning: This is a decision system for optimum design of the flow of materials in converting raw materials into the finished products (in a multi-stage manufacturing system). Traditional industrial engineering tools (Salvendy, 1992) are effective as visual aids. Optimum process routes minimizing the total production time (or cost) can be determined by dynamic programming or network analysis (Hitomi, 1978).

Line Balancing: As in a progressive assembly line where successive production stages (workstations) take the form of a conveyor-like system and work is performed continuously, a balance among production stages should be kept in such a way that a smooth material flow is obtained by almost equalizing the production times at all production stages, thus minimizing idle time at the workstations. This line balancing aims at minimum cycle time, minimum number of workstations, optimal grouping of work elements, etc. (Kuroda, 1984)

Logistics Analysis: From a broader perspective, the flow of materials constitutes a serial functional chain of procurement, manufacture, distribution, inventory and sales, as mentioned previously (Fig. 2). Through these activities raw materials are procured from outside suppliers, processed and assembled at workshops, stored in warehouses as inventories, and finished products are delivered to consumers as commodities through distribution channels. Transportation-type linear programming, the shortest-route analysis, etc. are applicable to the optimal decision of this problem. Logistics management plays a role in this field (Magee et al, 1985).

Decision Problems in Production Scheduling

Job Sequencing: This determines the order of processing jobs to be performed on a single machine with attention being directed to the permutation of schedules. Several basic rules have been developed for obtaining an optimal schedule with respect to the evaluation criteria used (French, 1982). In addition, feasible schedules are made by dispatching the jobs with an appropriate priority rule according to a certain measure of performance.

Operations Scheduling: This determines the order and schedule (drawn as a Gantt chart) for processing several jobs on several machines, as in a machine shop. A few rules for this purpose have been developed for flow-shop scheduling and job-shop scheduling, such as Johnson's algorithm, Petrov's method, the graphical method, the group scheduling technique (Ham et al. 1985,) OPT (Optimized Production Technology) (Baudin, 1990), etc.

Project Scheduling. In long-range scheduling, as in the construction of a new factory, ship, highway, etc. which comprises many and varied kinds of work elements, a reasonable schedule must be made for a smooth and effective implementation of production. Typical solution techniques for project scheduling; include PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) (Moder et al., 1983).

Decision Problems in Production Control

Control of Logistics: This is the control function for the flow of materials. It includes (Hitmoi, 1975):

- Purchasing control: Controlling the acquisition of production resources (factors of production).
- Production control (in a narrow sense) (or process control): Controlling the time (due date) and quantities to be produced.
- Quality control: Assurance of the desired quality for finished products.
- Sales control: Meeting the target of sales.

- Inventory control: Control for excess storage and shortages. This function is often combined with production planning.

Control of Production Resources. This is a control function for the factors of production. It includes:

- Personnel control: Acquiring human resources and skills.
- Facilities control: Effective use and maintenance of production facilities.
- Cost control: Controlling the cost required for production.

JIT Production: One of the methods in the field of production control is JIT (Just-In-Time) production, which is the Japanese-style manufacturing system with QC (Quality Control)-circle activities/TQM (Total Quality Management) (Hitomi, 1985; 1992). The principle of JIT is to make or supply 'the required product items in the required amounts at the required time,' thereby resulting in minimum, even zero, inventory. This valuable principle, however, is not new, in that this was advocated previously in 1928 as the laws of production control, even including 'at low prices' (Alford, 1928). The production schedule is input only at the final stage of the manufacturing system, then the demanded items are withdrawn from the previous stages with the circulation of *karbans* (cards), on which the items and their quantities needed are indicated. In this sense, this production system is known as the "pull-through system" rather than the usual "push system".

The principle of JIT is to make or supply 'the required product items in the required amounts at the required time'.

Cost Management: Cost control or cost management is concerned with economic production. This constitutes the "flow of cost" in the process of transformation of raw materials into finished products through the successive stages of the manufacturing system. The total cost is composed of the manufacturing cost and the commercial cost. The former is made up of direct and indirect costs, each of which contains the material cost, the labour cost, and the overheads. The latter is made up of the general administrative and sales expenses. Addition of an appropriate profit to the total cost makes the selling price (full-cost or mark-up pricing method). The average figures in percentage of the cost components against the total cost are indicated in Fig. 5 for Japan's small and medium manufacturing enterprises in 1990.

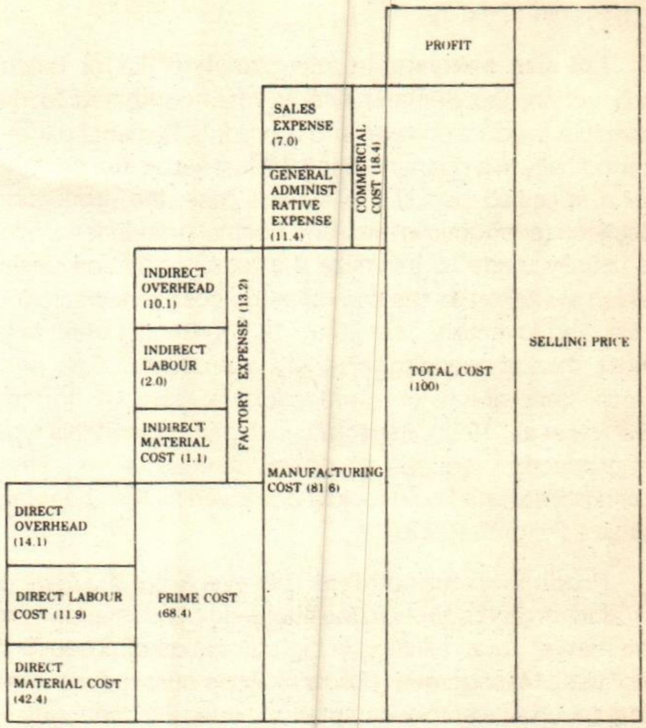

Fig. 5 The product cost structure. Figures in parentheses indicate the average percentage of the cost components against the total cost in the case of Japan's small and medium manufacturing forms in 1990.

Manufacturing Strategy

Computer-Integrated Manufacturing (CIM). CIM is a computerized system which integrates the computer aids of the following three different functions with a common database, and has the following contents (see Fig. 6) (Hitomi, 1989b):

- **Computer aid to the production function** automated flow of materials: [procurement-] production-quality control, process control, cost control [-distribution/sales]) – Computer-Aided Manufacturing (CAM).
- **Computer aid to the design function** (automated flow of technological information: [research and development-] product design-process design-lay-out design) – Computer-Aided Design (CAD).
- **Computer aid to the management function** (automated flow of managerial information: sales planning-production planning-operations scheduling) – Computer-Aided Planning (CAP).

Thus, integration of the automated flow of materials and automated flow of information is a concept of the CIM

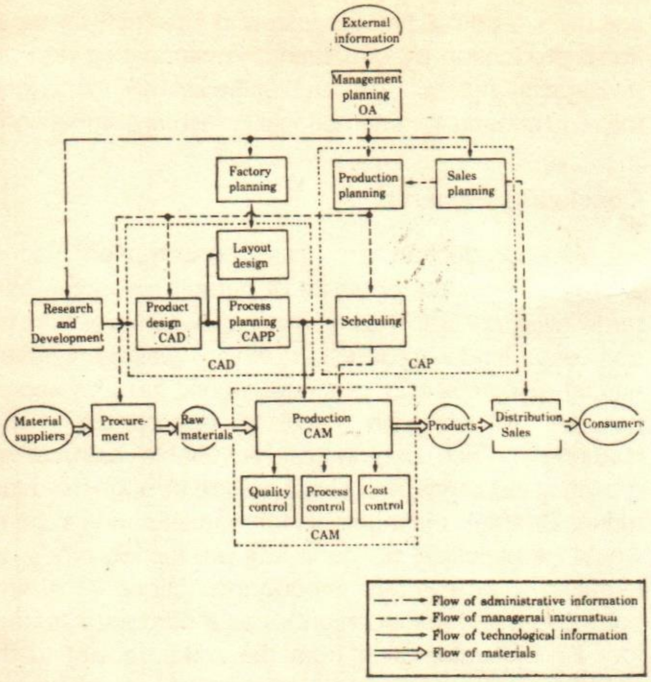

Fig. 6. Framework of functions involved in manufacturing and computer aids: CAD, CAM, CAP and OA.

and of "Manufacturing Systems Engineering" (Hitomi, 1990c). CIM is also a realized mode of the "System Integration (SI)" with the following three features (Matsuda, 1990):

- **Syncretism**, integrating different fields while maintaining their own autonomy
- **Symbiosis**, obtaining symbiotic gain
- **Synergy**, synergistically obtaining amplification effects.

CIM was first advocated in 1973 by J. Harrington (Harrington, 1973). In application, CIM is the integration of three functions: production, sales and technology. It ensures reduction of the lead time and flexible adaptation to large-variety, small-batch production through the computerized processing of the IMS – entire processes from order receipt to product shipment. A common definition of CIM has not yet been established, but it can be understood as 'a flexible market-adaptive strategic manufacturing system which integrates three different functions – design, production, and management through the information network with computers' (Hitomi, 1993).

CIM is the integration of three functions: production, sales and technology.

Recently an aspect of the information flow is understood as a "SIS (Strategic Information System)" which was coined by C. Wiseman in 1985 (Wiseman, 1988). SIS is mainly concerned with efficient operations of "service" industries. It is important to note that CIM is not a mere information system as SIS, but CIM is deeply concerned with "goods" production.

Flexible Production: Technology-centered full automation mainly comprising highly advanced production technologies, is not only insufficient in flexibility but is also confronted with a lack of innovative flexibility, greater vulnerability to failure, and, above all, neglect of human skills, robbing workers of their pride and pleasure of work, in spite of an enormous amount of capital investment '3,600 billion yen (US $ 26 billion) in 1989' (Wobbe, 1990. J. Harrington, 1973) mentioned that "CIM does not mean an automated factory; humans play a large part in CIM'. Manufacturing a variety of products of super-high quality with the use of high technologies but still drawing heavily on skills of workers is what "flexible production" (Hitomi, 1987) or "human-centered" (anthropocentric) systems (Cooley, 1987) is all about.

Manufacturing a variety of products of super-high quality with the use of high technologies but still drawing heavily on skills of workers is "flexible production"

Strategy of CAM (Unmanned small-lot production for a variety of products): An ideal CAM intends to eliminate direct workers. Since the direct labour cost accounts for more than ten per cent in the total costs in the case of small-and medium-sized manufacturers (11.9 per cent in 1990; see Fig. 5), it is expected to reduce at least 10 per cent of the production costs, bringing about a substantially remarkable benefit. CAM is not required for automation for single-item mass production, which can be implemented efficiently by automatic lathes, special-purpose machine tools, transfer machines, and LCA(Low-Cost Automation) systems. However, multi-product, small-batch production reflecting today's market needs for large variety, calls for CIM. Specifically, FMSs (Flexible Manufacturing Systems) are employed as the most advanced production facility of CAM. An FMS provides extensive flexibility for versatile manufacturing as to parts, products, quantities, processes, facilities and equipment by operating multi-function machine tools such as machining centers and turning centers, robots, pallet pools, conveyors, automatically guided vehicles and automated warehouses, via computer control. Efficient integration of both flows of materials and information is realized in an FMS.

Strategy of CAD (Quick design and product development): The most advantageous function of CAD is quick design and drawing of parts and products. CAD ensures design and drawing of parts and products with appropriate accuracies and qualities for JIT delivery demands by the market for large-variety, small-batch production. Benefits from CAD also include substantial reduction of design lead time and automated preparation of process design (CAPP) and numerical control (NC) programs. In other words, the CAD/CAM functions are provided. Computer aids in the field of design provide easy structural analyses by means of the finite element method (FEM) which treats characteristics analyses of displacement, accuracy, vibration and heat/fluid transfers. Optimization analyses are also made with greater ease using mathematical programming techniques, system theory or artificial intelligence (expert systems). This optimum design via computers is often called CAE (Computer-Aided Engineering); it ensures the optimum accuracy and strength and gives an edge in business competition when used in conjunction with the CAD/CAM.

Strategy of CAP (Reduction of lead time and flexible production management) Computer-aided production management is characterized by quick production planning and scheduling for producing a variety of products to meet the market needs. Reduction of manufacturing lead time and JIT deliveries are also expected, resulting in improvement of service to customers and giving an edge in severe business competition.

Strategy of OA (Sales promotion, corporate automation and global production): A practical objective of CIM is to integrate production and sales. The administrative function (flow of administrative information: management planning – factory planning) to make such an integration effective deals with strategic planning. OA helps computerization of this activity (see Fig. 6). In addition, automation of the marketing and sales functions based on this OA is expected to result in a 10 to 30 per cent increase of sales (Moriarty and Swartz, 1989). Through corporate automation, product orders are transmitted via real-time communications between the corporate office and sales branches, immediately analyzed by the interoffice information network (CAP) and processed for design (CAD) and production (CAM). Then the purchasing requests are immediately given to external suppliers of raw materials and parts. Additionally, a step toward an effective international production by structuring, implementing and administrating a global CIM can thus be established to meet the requirements for international industrial competition.

Concluding Remarks

Mass production and mass consumption lead to enormous amounts of waste of natural resources by a throw-away culture. It is important to switch over from the non eco-friendly production which wastes valuable natural resources and generates public hazards and air pollution to establish "socially appropriate manufacturing", which contributes reasonable gain, stable growth of industries, and social welfare through manufacturing. Strategic management for manufacturing systems would be beneficial to this useful production mode, integrating three different important functions – design, production, and management – as a corporate strategy for flexible automation from the order receipt to the product shipment to reflect a vast variety of consumers' needs, utilizing a high-tech CIM together with human-centered systems.

References

Alford, L.P., (1928), Laws of Management Applied to Manufacturing, Ronald Press.

Baudin, M., (1990), Manufacturing Systems Analysis, Yourdon Press.

Cooley, M., (1987), Architect or Bee — The human price of technology (new ed.), Chatto & Windus and the Hogarth Press.

French, S., (1982), Sequencing and Scheduling. Ellis Horwood.

Gutenberg, E., (1955), Grundlagen der Betriebswirtschftslehre, Bd I: Die Produktion (in Germany/Springer).

Ham, I., Hitomi, K. & Yoshida, T., (1985), Group Technology, Kluwer Nijhoff.

Harrington, J.Jr., (1973), Computer Integrated Manufacturing, Industrial Press.

Hirsch, B., T. Kuhlmannn & C. Lischke, (1992), Produktionskoordinierung in der Unikatfertigung (in Germany), Zeitschrift fuer wirtschaftliche Fertigung und Automatisierung, Vol. 87.

Hitomi, K., (1972), Decision Making for Production (in Japanese/Chuo-Keizai-Sha).

Hitomi, K., (1975), Theory of Planning for Production (in Japanese/Yuhikaku).

Hitomi, K., (1976), Analysis of production models: Part I-The optimal decision of production speeds. AIIE Transactions, Vol. 8, No. 1.

Hitomi, K., (1978), Production Management Engineering (in Japanese/Corona Publishing).

Hitomi, K., (1979), Manufacturing Systems Engineering (Taylor & Francis).

Hitomi, K., (1985), The Japanese way of manufacturing and production management. Technovation, Vol. 3, No. 1.

Hitomi, K., (1987), Multi-product, Small-batch Production — A text (in Japanese/Daily Technical Newspaper Company).

Hitomi, K., (1989a), Non-mass, multi-product, small-sized production. Technovation, Vol. 9.

Hitomi, K., (1989b), Essentials of Computer-Integrated Manufacturing Systems (in Japanese/Ohm Publishing).

Hitomi, K., (1990a), Essentials of Manufacturing Systems (in Japanese/Dobunkan Publishing).

Hitomi, K., (1990b), Manufacturing Systems Engineering (2nd ed. in Japanese/Kyoritsu Publishing).

Hitomi, K., (1990c), Manufacturing Systems Engineering: The concept, its context and the state of the art. International Journal of Computer Integrated Manufacturing, Vol. 3, No. 5.

Hitomi K., (1991a), Introduction to Manufacturing System Engineering (in Japanese/Kyoritsu Publishing).

Hitomi, K., (1991b), Strategic integrated manufacturing systems: The concept and structures, International Journal of Production Economics, Vol. 25, Nos. 1-3.

Hitomi, K., (1992), Present trends and issues in Japanese manufacturing and management. Technovation, Vol. 12, No. 3.

Hitomi, K. (ed.), (1993), Principles of Computer-Integrated Manufacturing — Computer-aided design, manufacturing, and management (2nd ed. in Japanese/Kyoritsu Publishing).

Huebner, H., & Hoefer, H., (1984), Strategy oriented production management. In: Advances in Production Management Systems, edited by Doumeingts, G., & Carter, W.A. (Elsevier).

King, J.R., (1975), Production Planning and Control (Pergamon Press).

Kuroda, M., (1984), Line Balancing and Its Application (in Japanese/Daily Technical Newspaper Company).

Magee, J.F., W.C. Copacino, & D.B. Rosenfield, (1985), Modern Logistics Manageemnt (Wiley).

Martino, R.L., (1972), Integrated Manufacturing Systems (McGraw Hill).

Matsuda, T., (1990), From automation technology to SI (in Japanese). Automation Technology, Vol. 22, No. 4.

Moder, J.J., Phillips, C.R. & Davis, E.W., (1983), Project Management with CPM, PERT and Precedence Diagramming (Van Nostrand Reinhold).

Monden, Y., (1983), Toyota Production System (Industrial and Management Pres). Moriarty, R.T. & G.S. Swartz, 1989, Automation to boost sales and marketing. Harvard Business Review, Vol. 67, No. 1.

Ohno, T., (1978), Toyota Production Systems (in Japanese/Diamond-Sha).

Orlicky, J., (1975), Material Requirements Planning (McGraw-Hill).

Salvendy, G., (ed.), (1992), Handbook of Industrial Engineering (2nd ed./Wiley).

Wiseman, C., (1988), Strategic Information Systems (Irwin).

Wobbe, W., (1990), Science, technology and society towards twenty-one century (in Japanese), Economic Review, Vol. 39, No. 9. ☐

"It costs a lot to build bad products."

– Norman R. Augustine

Progress Automation & Information Integration

S. Subba Rao, T.S. Raghunathan & Mark A. Vonderembse

Automation and integration are vital for improving the competitive position of manufacturing organizations in a rapidly changing market place. Automation is the ability of the production system to physically respond to environmental changes with the least amount of human intervention. Information integration means the ability of the system to observe, process, transmit and share all kinds of information pertinent for various kinds of actions by the production system. The effects of automation are easily perceived. On the other hand the value added by information systems and information integration is less tangible and less directly measurable. Most organizations follow the automation route which will improve efficiency which justifies automation while information integration gets related to the background whereas they should strive for a balance between the two. Based on a limited field study the authors propose a conceptual model for organizations to strive towards achieving this balance.

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During the recession of the late seventies and earl eighties, it became clear that U.S. manufacturers had t respond to the challenges presented by foreign com petitors. These responses included traditional produc tivity improvement programs aimed at lowering operatin costs [Skinner, 1986; Fortune, 1992], JIT, quality circle empowerment, and continuous improvement [Schoen berger, 1986]. They also included investments in techno ogy such as robots, flexible manufacturing systems, an computer aided design (CAD) work stations with the u timate goal to achieve the elusive benefits of Compute Integrated Manufacturing (CIM) [Doll & Vonderembs 1987; Parthasarathy & Sethi, 1992]. These investment often focused on improving a part of the productic process and were implemented as islands of automatio with limited understanding of how they would form a integrated whole. These efforts helped some US firms t increase product quality, cut delivery lead-time, and low product costs. Unfortunately, in most industries the have not helped firms to close the gap with their com petitors because the competition is continuing to improv [Skinner, 1986; Kupfer, 1992].

Why, after more than a decade of trying, have U manufacturers been unable to match the competition The simple answer may be that US manufacturing opera tions require more than fine-tuning through productivit improvement programs and the automation of selecte tasks in the manufacturing system. By trying to squeez out higher efficiency from tighter discipline and improve attitudes on a person-by-person and department-by department basis, organizations fail to examine carefull the structure of the production system itself [Skinne 1986]. Many leaders in industry, government, and highe education, as well as advocates of Just-in-Time conten that US firms require a new approach to manufacturin [Huber, 1984; Suzaki, 1987; Hayes, et al, 1988; Drucker 1990; Zipkin, 1991].

In responding to this challenge, Richard Cyert [1985] ·ted that US manufacturers must "automate, migrate, or aporate". More than two decades ago, Lawrence and .rsch's study [1967] of complex organizations indicated at high performing organizations tend to have higher /els of integration at all levels. Are automation, which yert advocates, and integration (in the sense of informa- n integration), which Lawrence and Lorsch's study indi- tes, keys to this new approach to manufacturing? Both ademicians [Dollinger, 1984; Zmud, 1984; Wyckoff and ›rnatzky, 1988], and practitioners [Mitchell, 1986] con- der automation and integration as important issues in uilding manufacturing enterprises which can prosper in ighly competitive global markets.

Vonderembse et al (1992), define and discuss the sues of automation and integration in the industrial as ell as in the post-industrial stages of manufacturing. owever, little research has focused the combined effects f integration and automation, and on balance between tegration and automation; this article is meant to fill the ap so that managers can understand when and what ey need to do for attaining effective and efficient nanufacturing systems.

omputer Integrated Manufacturing

A traditional approach to manufacturing in the in- lustrial stage is described by Utterback and Abernathy's .975] dynamic model of process and product innova- on. Their model divides the industrial stage into three arts which they labelled uncoordinated, segmental, and ystemic phases, the characteristics of which are shown table 1.

Process automation in the industrial stage (Utterback & Abernathy, 1975) resulted in lower labour costs during the segmental phase and led to the creation of islands of automation in the systemic phase. In the post-industrial stage of manufacturing, these islands of automation need to be integrated through creative use of information systems technology which is the central theme of Computer Integrated Manufacturing (CIM).

"CIM refers basically to the data-handling capabilities of the manufacturer. It is a sophisticated system for gathering, tracking, processing and routing information that links purchasing, distribution, and financial data with design, engineering, and manufacturing data to expand and speed the knowledge available to employees and managers. CIM systems will use interactive data bases and hierarchical control systems coupled to advanced CAD systems, modelling and simulation systems, computer-aided engineering (CAE) systems, production process planning systems, flexible manufacturing systems and/or hard automation process, material handling systems and automated inspection/quality assurance systems". [Manufacturing Studies Board, 1986]. The essence of this definition is captured in Figure 1, which illustrates the structure of CIM.

The thrust of CIM is in integrating various functions in an organization through the use of information systems and communication technology. CIM forces managers to think in terms of an extended enterprise in which manufacturing becomes an integral and a vital part of a value-adding chain that couples customers at one end and the suppliers at the other end along with design, engineering, marketing, finance, and other functions. The

ble 1: The Phases of Industrial stage of Manufacturing

ıaracteristics/Dimension	Uncoordinated	Segmental	Systemic
ate of Product/Process	High	Moderate	Low
roduct Diversity	High	Moderate	Low
olume of production	Low	Moderate	High
ficiency of production	Low	Moderate	High
ost of manufacture	High	Moderate	Low
Machine Tools	General Purpose	Customized	Highly automated
exibility	High	Moderate	Low
roduct Customization	High	Moderate	Low
elationship between process elements	Loose	Coupled	Highly Integrated
esponse to change	Easy	Difficult	Very Difficult
ack Resources	High	Medium	Low
Competitive Mode	Custom Design General Purpose High Margin		Vertical Integration Long runs Economies of Scale

ource: Abernathy & Utterback, 1975

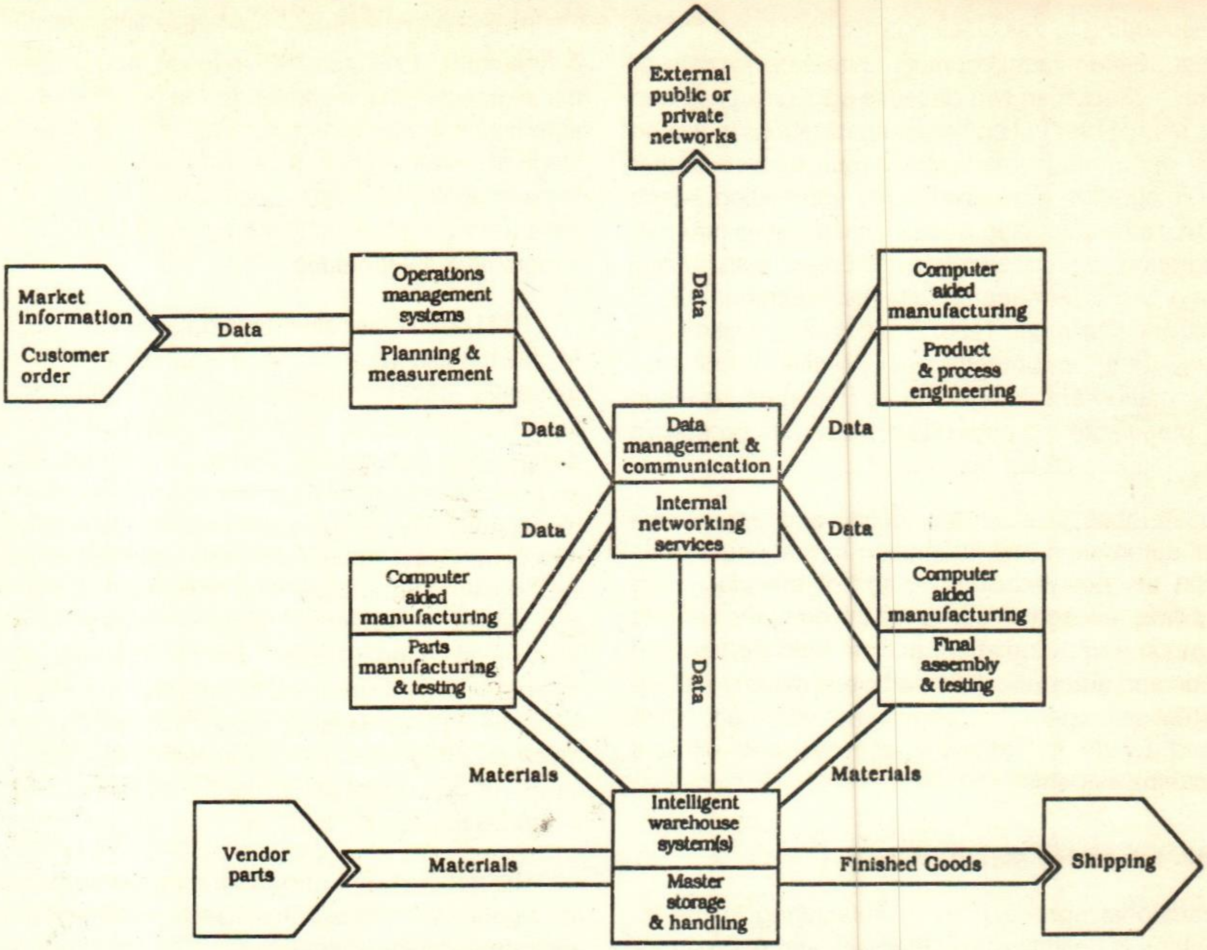

Fig. 1 Structure of computer-integrated-manufacturing (adapted from Curtin, 1984)

producer and the vendor are operationally and spatially independent, yet they are closely tied-in temporally because of the need to have shorter lead times.

> **CIM is a sophisticated system for gathering, tracking, processing and routing information that links purchasing, distribution, and financial data with design, engineering, and manufacturing data to expand and speed the knowledge available to employees and managers.**

CIM enables the organization to compete successfully, simultaneously along the four dimensions of quality, cost, flexibility and delivery performance.

CIM Coordination Between Functions

CIM requires a high degree of coordination between functional units like manufacturing, marketing, engineering etc. Such coordination can be achieved through integrated information systems. In the traditional manufacturing set-up, inventories are built to decouple various stages of production processes. But in the CIM set-up inventories are cut to the lowest levels and the stages are tightly coupled. The tight coupling extends beyond the walls of the factory, all along the value-added chain starting from the customers through the production process right up to the suppliers. The various players along this value added chain should know how to manage their production and systems along the four dimensions of quality, cost, flexibility and delivery. Manufacturing which used to plan on batch production should now understand the flexibility available through the CIM technology and should be willing to coordinate with marketing to meet fluctuating market demand by shifting to small batch production and reducing inventories. Marketing should use this opportunity strategically. Such demands on the system require faster dissemination of information and quick response to market changes by various functions of the business.

ɔduct Design

Similarly, product design needs to coordinate with ɪrketing and the customers upstream as well as the ɪnufacturing downstream. Most of the manufacturing l be customer driven since satisfying the customer ɔng with time-based competition is becoming the ategic aim for organizations. With shorter life cycles of oducts and customer requirements changing at a rapid te, product design has to be done almost synchronous- with the process design with the product designers orking in teams with the people from marketing, en- neering and manufacturing. These refinements point to ɪe need of sharing common data bases, rapid com- ɪunication and high degrees of coordination.

> **With shorter life cycles of products and customer requirements changing at a rapid rate, product design has to be done almost synchronously with the process design.**

Technologies and Organization

At the plant and lower levels, flexibility available through computer controlled flexible automation requires rethinking and rearrangement of the production process. At the same time coupling of machines and processes increases information flow. Handling of this increased information flow in existing telecommunication environment where protocols are not standardized poses serious problems. At the corporate and industry levels, sharing and managing information flows poses serious challenges. Converting a traditional manufacturing set-up to a high-technology set-up is a complex process requiring large capital investments. Such a change also requires a skilled workforce. The latter aspect can lead to replacing the existing work force or in extensive retraining of an existing but down-sized, work force. Managers may lack the necessary human resource management skills to handle the problems that are likely to be created by the changeover of technology.

A further challenge comes from the need to have a clear understanding of technology and its effect on the organization. Organizations change much more slowly than technology [McKenney 1982]. Introduction of technologies into organizations which are not ready for them can lead to improper utilization of resources and lost opportunities. The scope of CIM at the corporate and plant levels (we have omitted the cell and work section levels for purposes of brevity) as it relates to the areas of business, production and design is shown in table 2. Given such a scope for CIM, the organizational structure to handle CIM will have to be different. Coordination and implementation of these technologies will not only require different premises and patterns of management thinking but also different organizational structures which will cut across the traditional functional orientations – the traditional hierarchical, over-the-wall, command-and-control type structures to more open, matrix and networking type structures.

Field Study

To understand some of the above issues in some depth, the authors undertook a limited field study in which they visited and conducted in-depth interviews with the manufacturing and information systems executives of a few companies involved in planning and implementing advanced manufacturing technologies including CIM. From the list of organizations who were the recipients of the Society of Manufacuturing Engineers (SME) awards for implementing CIM, three were chosen based on the convenience and availability of mutually agreeable dates for the visits and interviews. The three represented three different industries: automobile, earth moving machinery, and electrical component. All three belonged to the Fortune Five Hundred category. We shall call these organizations A, B and C. Our objectives during the visits were to understand:

- The mechanics of adopting and implementing CIM
- The stage they were in, namely how far along were they in process automation and information integration
- The effect of CIM on a number of internal characteristics like quality, cost, inventories and
- Whether there were similarities in implementing CIM.

Organization A: The CIM project was conceived and implemented when this organization was a part of one of the automobile giants. One of the main reasons for them to introduce CIM was the fact that the parent organization was favourably inclined to approve high-tech proposals which heavily used robotics and automation. This organization converted one of their engine manufacturing lines to a CIM set up. In this fully implemented set up, transfer lines had been eliminated. Machining of the engine blocks and assembly of engines – custom made to order – was achieved by mounting the engine blocks on

Table 2: Scope of Computer-integrated Manufacturing

	Business							Design	
	Resource management	Economic accounting	Production planning	Part planning	Production control	Part processing	Document preparation	Test	Synthesis and analysi
Corporation	Trend analysis Facility planning Strategic planning Merger/acquisition Synergistic product Production levels Data management	Projections Simulation	Scheduling Facility planning Materials requirements planning R&D	Machining technology data base Group technology R&D	Data management	R&D base Testing	Parts data base Bills-of-materials GT/part Classification Data management	Test data aided Field report data base Computer-aided engineering	Computer-engineering Productibility analysis Design standards
Plant	Plant layout Inventory Scheduling Manpower utilization Make/buy decision Data management	Cost tracking Customer billing Customer order Normal accounting Make/buy EOQ Cost estimating Process justification	Materials requirem. planning Bill-of materials Time standards Scheduling Make/buy decision Facility planning Capacity planning Plant layout Manpower utilization GT/operation sequence	Machining technology data base GT/plant retrieve Computer-assisted process planning R&D Part program Cost estimating	inventory Routing/scheduling Material handling QC/QA Maintenance Purchase/receive Data management Standard methods	R&D Testing	Parts data base Computer-aided design and drafting Bill-of-materials GT/part classification Tool/fixture design & coding Data management	Computer aided engr. Testing	Computer-aided engr. Design analysis System modeling Productibility analysis GT/design retrieval Design standards

(Source: Computer-Integrated Manufacturing — From Vision to Reality, Production Engineering, 1983.

pallets which moved from one operation center to another using automated guided vehicles (AGV). The routings were based on machining and assembly requirements and the availability of flexible machining centers. The movement, routing, loading on to and out of the machines etc. were all controlled by a central control station computer as well as satellite computers and programmable logic controllers (PLC). All operational information like tool wear, quality etc. were monitored, analyzed and displayed to operators for appropriate interventions as and when needed. The CIM setup ensured that all the parts required for assembly were picked and placed on assembly stations so that the assembly can be completed without any error and to specification. The CIM set up for this particular engine line greatly contributed to improved quality, reduced labour, higher output, on-time delivery, and competitive advantage. However, the CIM set up stood alone serving the manufacturing of one engine line and was not fully integrated with the other functions of the oorganization like marketing, finance and accounting. There was indeed a lack of information integration. This set up was an example of achieving high automation without spending resources on information integration. Though the CIM set-up could respond to market changes quickly, there was a delay in receiving the information regarding market changes due to lack of information integration.

Organization B : The organization is part of a multinational company with 32 plants worldwide. It produces tractors, transmissions, pipe layers, and parts for sister facilities. The facility is a modern machining and assembly operation. The factory layout has been rearranged to streamline production, cutting space and flow times. Cells combining existing machinery with automated machine tools and material handling equipment have been organized for streamlining the flows. Cells process entire families of parts from start to finish and supply the assembly line just-in-time. The manufacturing activities are being *computer-coordinated* with other functions like product development and design, forecasting demand, ordering inventory, sales, and distribution. This facility represented a situation where moderate levels of automation and computer integrated information have been achieved and they have yet to achieve complete computer integrated manufacturing.

The various plants in the company, including the technical center and the worldwide parts distribution center, are connected via computers and communications networks. The parts distribution network consists of 13 departments, 9 depots, and over 1400 dealer stores all over the world. Master computer systems tie together the distribution network and assure prompt parts delivery (99.5% delivery in 48 hours). Computers and telecommunications link a worldwide network of dealers. The company has thus in place a system where high levels of information integration is achieved and higher levels of integration are feasible. The company strategy has been to move carefully towards computer integration on a broader scale, linking worldwide product engineering, logistics and factory operations with a single electronic network. If this strategy can include integration with business functions (which is feasible given their level of information and communications systems) like finance, inventory, marketing and sales, the company will really evolve towards true CIM. It appears that the company strategy is one of balancing resource allocation between process automation and information integration.

With the current levels of cellular manufacturing and some flexible machining systems, the company has already reaped some of the benefits of CIM: reduction in manufacturing space, reduction in flowtimes, reduced costs, higher quality, faster delivery, and increased customer satisfaction. Moving towards complete CIM will definitely move the company to realize even higher levels of the benefits that accrue from CIM.

Organization C: This organization is a part of a multinational company. It supplies power turbines and spare parts for those turbines. There are two manufacturing plants, one in Georgia and the another in New York. Both their plants are well connected through telecommunication facility. Within the New York plant, the site of the visit, product development, design, part distribution network, and other manufacturing functions are well integrated through computer and telecommunication network. For example, if a spare part order is received, the part drawing can be retrieved from their computerized storage. Required changes can be incorporated with their CAD system and the final drawing with the order can be transmitted to the shop floor through their computer network. The organization has implemented a well connected network which has helped them to achieve high levels of information integration. They have standardized their computing resources by entering into a long term contractual arrangement with one of the leading computer manufactures for both hardware purchase and software building. They have a very small corporate IS department which takes care of planning and policy and acts as a liaison between the IS supplier and the corporation.

But they have not invested much on hard automation. The plant is still using their old machines. There are not many flexible machines. It was said that they are in the process of replacing these old machines with modern flexible machines. If they install flexible machines and link these machines to their computer network they will become a fully integrated CIM facility.

Balance Between Automation and Integration

As reported in the literature, for various reasons, the adoption of CIM has taken place more in the direction of creation of large stand-alone applications and islands of automation rather than integrated setups [Doll and Vonderembse 1987, 1991, Commerce 1985, Gold 1982, Jelinek 1984, Rosenthal 1984]. Our limited field study, while supporting this observation, also points to the fact that organizations can also move heavily towards information integration, integrating the organization, and downplaying the automation factor. While process automation has helped to improve the efficiency of the manufacturing organization by creating islands of automation and stand alone systems, information integration is crucial for achieving overall organizational effectiveness. Managers need to have a conceptual understanding of process automation and information integration dimensions to achieve better organizationals effectiveness by balancing automation and integration.

A Conceptual Model

Automation and integration are important for improving the competitive position of manufacturing organization in a rapidly changing market place. In a general sense automation is described as the ability of the production system to physically respond to environmental changes with the least amount of human intervention. Information integration means the ability of the system to observe, process, transmit and share all kinds of information pertinent for various kinds of actions by the production system. The effects of automation are easily perceived. Automation adds value, reduces direct labour and the results of automation are thus tangible. This is also the reason why manufacturing organizations have embraced automation quickly. On the other hand, the value added by information systems and information integration is less tangible and less directly measurable. The result is that most organizations follow the automation route which will improve efficiency which justifies automation while information integration gets relegated to the background. The point, however, is that organizations should strive for a balance between the two. Such a balance could be attained at different levels of automation and integration depending upon the organization, the industry and the business climate.

Automation adds value, reduces direct labor and the results of automation are tangible. Value added by information systems and information integration is less tangible.

A conceptual model based upon the field study conducted by the authors and previous studies in related areas [Commerce 1985, Gold 1982, Rosenthal 1984]. for describing the location and trajectory for a CIM organization is postulated as follows:

The road to CIM is via both automation and information integration. At any point of time, an organization can be placed within the grid shown in Figure 2. An ideal CIM set-up will be located at the top right corner of the grid. The desirable zone is the diagonal band running from the bottom left to the top at the corner. The width of the band will depend on the industry or industry group which can be, or has to be determined empirically. The characteristics of organizations at the four corners of this grid are as follows.

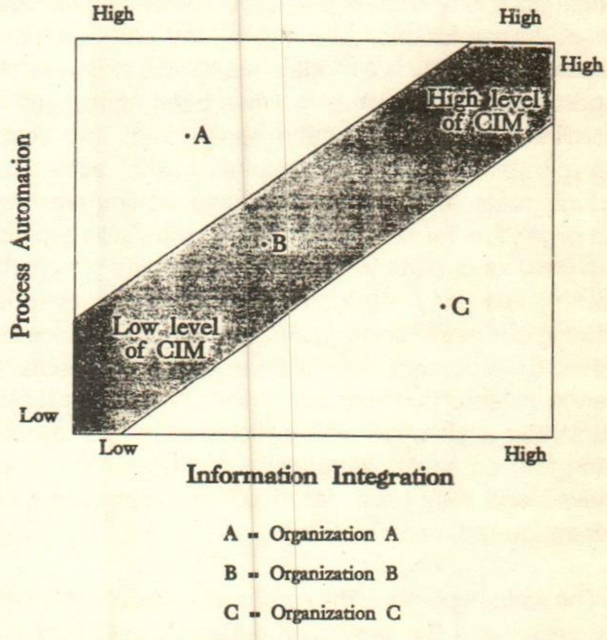

Fig. 2. Road to CIM.

Low automation and low integration

These organizations will be very similar to those described by Abernathy and Utterback (1975) as in the uncoordinated stage of manufacturing. They are characterized by a large labour force with low technical competencies, large raw material, in-process and finished goods inventories. The cost of manufacture is usually high. The organizations are usually of the job-shop type having general purpose machines and tools and cater to highly segmented local markets where competition is nonexistent.

High automation and low integration

if there is unplanned and uncoordinated growth, organizations tend to invest primarily in automating their manufacturing processes to reduce direct labour content and improve quality. In these organizations one will find islands to automation. Due to process automation, raw material and in-process inventories will be under control. Technical skill levels of the labour force will be high. Market feedback will be low and slow. Because of a lack of integration among functions, the ability of production to react to changing market conditions will only be moderate. The organization can operate competitively in catering to small number of customers with stable demands.

Low automation and High integration

The organizations at this end of the grid will be in a position to react to market changes quickly because of their ability and capacity to transmit, absorb, and act on information quickly achieved by high integration of various functions through information integration. However, this may not result in considerable competitive advantage because of the low degree of automation. The cost of manufacture is moderate and inventories levels will be moderate to low. These organizations tend to have labour forces of moderate size with moderate technical skills. Their investment in information and telecommunication technologies will be high.

High automation and High integration

Organizations at this corner will be reaping the benefits of CIM. With a high level of information integration, they can react to market conditions quickly and compete on the dimensions of flexibility and delivery. The information integration enables them to successfully use techniques like JIT and TQC. They are characterized by lean inventories, small but highly skilled labour forces and lower costs resulting from a high degree of automation. They also tend to produce high quality products.

Table 3 summarizes these characteristics of the organization.

To reap the benefits of both integration and automation, an organization should first identify where it is located in the grid. This can be done by studying the various characteristics of process variables in table 3. Once the position is identified, it is a strategic decision to

Table 3: Characteristics of Organizations

Attributes	Nature of attribute	South West Quadrant	North West Quadrant	South East Quadrant	North East Quadrant
In-process inventory	A1	High	Moderate	Low	Low
Finished goods inventory	A1	High	Moderate	Low	Low
Quality	A2	Low	High	Moderate	High
Cost of manufacture	A1	High	Moderate	Moderate	Low
Ability to change to market demand	A2	Low	Low	High	High
Market feedback	A2	Low	Low	High	High
Competitive environment	B	None	Small number of customers	Large number of customers	Large number of customers
Functional integration	A2	Low	Low	High	High
Size of labour force	A1	High	Low	Moderate	Low
Technical competence of labour force required	A2	Low	High	Moderate	High
Technologyy of machine tools	A2	Low	High and Flexible	Low	Flexible and Integrated
Technology — computers and telecommunications	A2	Low	Moderate	High	High
Management Philosophy	A2	Conservative and Reactive	Conservative and Reactive	Progressive and Proactive	Progressive and Proactive

*Note
A1 — Controllable, quantitative
*2 — Controllable, quantitative
— Uncontrollable

move the organization from its current position to the required position where it is compatible with industry norms. It is a question of resource allocation along any one of the dimensions or both. Because there will always be a resource constraint, by properly balancing resource allocation between the two dimensions, an organization can move towards its objective smoothly and can derive optimal benefits during the transition stage. The strategic objective should be to maintain proper balance between these dimensions because excessive investment in any one of the dimensions alone will be unproductive.

As pointed out by Drucker [1990], excessive resource allocation towards automation only will reduce flexibility and will reduce capability to change quickly. Similarly excessive integration without balanced automation reduces the ability to react to market changes and increases cost of manufacturing.

Allen Bradley Case

A good example of an organization which has implemented CIM is Allen-Bradley which is a subsidiary of Rockwell International corporation [Avishai, 1989]. Allen-Bradley manufactures industrial automation controls and systems. Before implementing CIM in this particular facility which produced contactors, Allen-Bradley used to sell the contactors at $16. But the competitors from abroad were selling similar contactors at a lower price of $8. So it became a competitive necessity for Allen-Bradley to manufacture and sell these contactors at less than half the originnal price. The initial pilot plant with hard automation could not bring down the manufacturing costs to an acceptable level. To meet the international competitive pressures and to manufacture contactors conforming to world-class standards, a task force was formed to plan and implement CIM system in the manufacture of these contactors. A totally paper-less, people-less environment with practically zero inventory was planned, approved and implemented. A fully computer-integrated and controlled plant was built and brought into operation in 1986. This plant produces 600 units per hour in any of more than 777 variations and in lot sizes as small as one.

The orders are directly entered into their order entry system. From then on, due to total information systems integration through different layers of computing systems, instructions to execute each order is developed. These instructions are passed on to computers which are controlling the highly integrated, automated machines. Following the instructions, contactors are manufactured according to specification. Due to the flexibility of the set up, batch sizes as small as one are possible. The Allen-Bradley Operation has become a show piece operation where total information integration and complete process automation had produced a CIM environment.

Conclusions

To become globally competitive, organization should balance the resource allocation between process automation and information integration. By identifying the position of an organization with respect to the industry it is in and the extent of development of automation and integration in that organization, it can prudently plan to spend future resources to achieve the balance between automation and integration for effective resource allocation decisions.

References

Avishai, B., "A CEO's Common Sense of CIM: An interview with J. Tracy O'Rourke, "*Harvard Business Review*, Vol. 67, No. 1, Jan/Feb 1989.

Commerce, United States Department of, *A Competitive Assessment of the US Flexible Manufacturing System Industry*, Office of Capital Goods & International Construction Sector Group, International Trade Administration, US Department of Commerce, US Government Printing Office, Washington DC, July 1985.

Curtin, F.T., "Planning and justifying factory automation systems," *Production Engineering*, May 1984.

Cyert, R., "Saving the smokestack industries," *The Bell Atlantic Quarterly,* Vol. 2, No. 3, Autumn, 1985.

Doll, W..J., & Vonderembse, M.A., "Forging a partnership to achieve competitive advantage: The CIM challenge," *MIS Quarterly*, Vol. 11, No. 2, June 1987.

Doll, W.J., & Vonderembse, M.A., "The evolution of manufacturing systems: Towards the post-industrial enterprise," *OMEGA: International Journal of Management Science*, Vol. 19, No. 5, 1991.

Dollinger, Marc J., "Environmental Boundary Spanning and Information Processing Effects on Organizational Performance," *Academy of Management Journal*, Vol. 27, No. 2, June, 1984.

Drucker, P.F., "The emerging theory of manufacturing," *Harvard Business Review*, Vol. 68, No. 3, May-June, 1990.

Fortune, "GM's Leaders Go on the Record," *Fortune,* March 9, 1992.

Goid, B., "CAM sets new rules for production," *Harvard Business Review*, Vol. 60, No. 6, Nov/Dec. 1982.

Goldhar, Joel D., & Jelinek, Mariann, "Plan for Economies of Scope," *Harvard Business Review*, Vol. 62, No. 6, November, 1983.

Hayes, Robert H. Wheelwright, Steven C., & Clark, Kim B., *Dynamic Manufacturing: Creating the Learning Organization,* The Free Press, New York, 1988.

Huber, George P., "The Nature and Design of Post-Industrial Organizations," *Management Science*, Vol. 30, No. 8, August, 1984.

Jaikumar, Ramchandran, "Post-industrial Manufacturing," *Harvard Business Review*, Vol. 64, No. 6, November-December 1986.

Jelinek, M. & Goldhar, J.D., "The strategic implications of the factory of the future," *Sloan Management Review,* Vol. 4, No. 4, Summer 1984.

Keen, P.G.W., "Value analysis: Justifying decision support systems," Vol. 5, No. 1 March 1981.

Kupfer, Andrew, "How American Industry Stacks up," *Fortune,* March 9, 1992.

Lawrence, Paul R., & Lorsch, Jay W., "Differentiation and Integration In Complex Organizations," *Administrative Science Quarterly,* Vol. 12, June, 1967.

McKenney, J.L., & McFarlan, F.W., "The information archipelago-maps and bridges," *Harvard Business Review,* Vol. 60, No. 5, Sep/Oct. 1982.

Mitchell, Russell, "How Ford Hit the Bull's-Eye with Taurus," *Business Week,* June 30, 1986.

Parthasarthy, Raghavan & Sethi, S. Prakash, "The Impact of Flexible Automation on Business Strategies and Organizational Structure," *Academy of Management Review,* Vol. 17, No. 1, January, 1992.

Production Engineering, "Computer Integrated Manufacturing: From Vision to Reality," 27 Nov. 1983.

Rosenthal, S.R., "Progress towards the factory of the future," *Journal of Operations Management,* Vol. 4, No. 3, May 1984.

Schonberger, R.J., *World Class Manufacturing: The lessons of simplicity applied,* The Free Press, New York, 1986.

Skinner, W., "The taming of lions: How manufacturing leadership evolved, 1780-1984," in *The Uneasy Alliance: Managing the Productivity—Technology Dilemma,* Edited by Clark, Hayes & Lorenze, The Harvard School Press, Boston, 1986.

Skinner, Wickham, "The Productivity Paradox," *Harvard Business Review,* Vol. 64, No. 4, July-August, 1986.

Suzaki, Kiyoshi, *The New Manufacturing Challenge: Techniques for Continuous Improvement,* The Free Press, New York, 1987.

Manufacturing Studies Board of National Research Council, *Towards a new era in US Manufacturing: The need for a national vision,* National Academy Press, Washington DC, 1986.

Utterback James M. & Abernathy, William J., "A Dynamic Model of Process and Product Innovation," *OMEGA: The International Journal of Management Science,* Vol. 3, No. 6, 1975.

Vonderebmse, M.A., Raghunathan, T.S., & Rao, S.S., "Integrate and automate: Closing the gap on competitors," *Working paper,* Universityy of Toledo, 1992.

Van de Ven, A.H., "Central Problems in the Management of Innovation," *Management Science,* Vol. 32, No. 5, May, 1986.

Wyckoff, Andrew W. & Tornatzky, Louis G., "State-level Efforts to Transfer Manufacturing Technology: A Survey of Programs and Practices," *Management Science,* Vol. 34, No. 4, April, 1988.

Zipkin, Paul, "Does Manufacturing Need a JIT Revolution?" *Harvard Business Review,* Vol. 69, No. 1, January-February, 1991.

Zmud, Robert W., "An Examination of 'Push-Pull' Theory Applied to Process Innovation in Knowledge Work," *Management Science,* Vol. 30, No. 6, June, 1984. □

Faith is to believe what we do not see; and the reward of this faith is to see what we believe.

– St. Augustine

The future, something everyone reaches at the rate of sixty minutes an hour, whatever he does, whoever he is.

– C.S. Lewis

ISO 9001: A Process Improvement Roadmap For A Small Electronics Manufacturer

J. Muñoz & P.F. Ostwald

New standards of international competition are challenging small manufacturers to improve their production as well as their business practices. To document their quality systems, many small producers are applying for the international certification that ISO 9000 provides. A small electronics manufacturer has teamed up with a local university to develop and implement a methodology that uses ISO 9001 requirements as a guideline for process improvement. This paper describes the main steps of such a methodology and the organizational structure to support it.

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Competition in electronics manufacturing is setting new standards in the global marketplace. Competitively priced products are the key to tomorrow's success. Although technical superiority and performance still remain crucial, price and operating costs are the baseline decisive criteria for customers in the market of small electronics goods. The goal is to provide the best product at a lower price and with the lowest operating cost. Costs must be reduced without sacrificing the technical superiority of products. Such a challenge demands proper documentation of a quality system. ISO 9001, the most stringent standard of the ISO 9000 series, presents a well suited framework that small manufacturers can follow to make Continuous Improvement (CI) a reality.

Why ISO 9001 ?

ISO 9000 is composed of a set of four standards:

- ISO 9004: Guidelines to interpret ISO 9001-9003.
- ISO 9003: Requirements for service and inspection functions.
- ISO 9002: Same as ISO 9003 plus requirements for design functions.
- ISO 9001: Same as ISO 9002 plus requirements for manufacturing functions.

ISO 9001, therefore, provides quality systems guidelines and requirements for organizations such as small electronics manufactures that design, develop, produce, install, and service their products. On the other hand, CI means productivity improvement and is more than eliminating defects or deficiencies in the product. It is more than reducing rework and scrap in the factory. CI is "quality of management." Quality of management is continuous improvement in the way employees do their work and manage their business. It is doing away with a the waste in materials, resources and time. It is doing the right things and doing them right the first time.

The effort to achieve continuous improvement at every level cannot be a short-term programme. It demands permanent commitment to identity and to eliminate from all business systems the waste that detracts from the ability to improve quality and productivity. A well documented quality system provides the means to identify and to correct inefficiencies. Figure 1 shows the documentation structure that ISO 9001 requires. It demands that the company quality policy be well known and understood by all members of the organization. Additionally, documents must describe processes and practices that are actually carried out to design and manufacture a product. The bottom line is to document what you do and actually do what you document.

The bottom line is to document what you do and actually do what you document.

Three elements compel manufacturers to implement CI and to document their quality systems according to ISO 9001 standards:

- *Changing competitive environment*: Major programme losses due to a lack of cost competitiveness and response to customer's complaints; increasing international competition; need to export to the Economic European Community and USE military budget cuts.
- *Changing customer environment*: Demands for higher product quality, reliability and warranties; demands for timely and complete deliveries; use of statistical process analysis to reduce manufacturing variation; vendor certification programs and realization that the low-cost high-quality producer has become a high criteria combination for vendor selection.
- *Changing employee environment*: Employees showing more and more the ability and desire to be involved in decision making; better educated people at all levels can generate more ideas for improvement; more importance is placed on environmental factors; there is the expectation of enjoying their work.

These elements combine to provide the structure and the environment that foster the commitment and involvement of management and employees.

CI Process

One of the first steps in the CI journey is to define two terms: quality and continuous quality improvement. Keeping the customer as the driver of all efforts, quality is defined as a verb, denoting action, rather than as a noun. Thus, "quality is the act of providing the customer with products and services that consistently meet their needs and expectations." "Consistently" means that there is minimal process variation. It means that flow time is always the same, conformance to specifications is the same, product performance is always the same, etc. Then, what is continuous quality improvement? Keeping in mind the definition of quality given above, "continuous

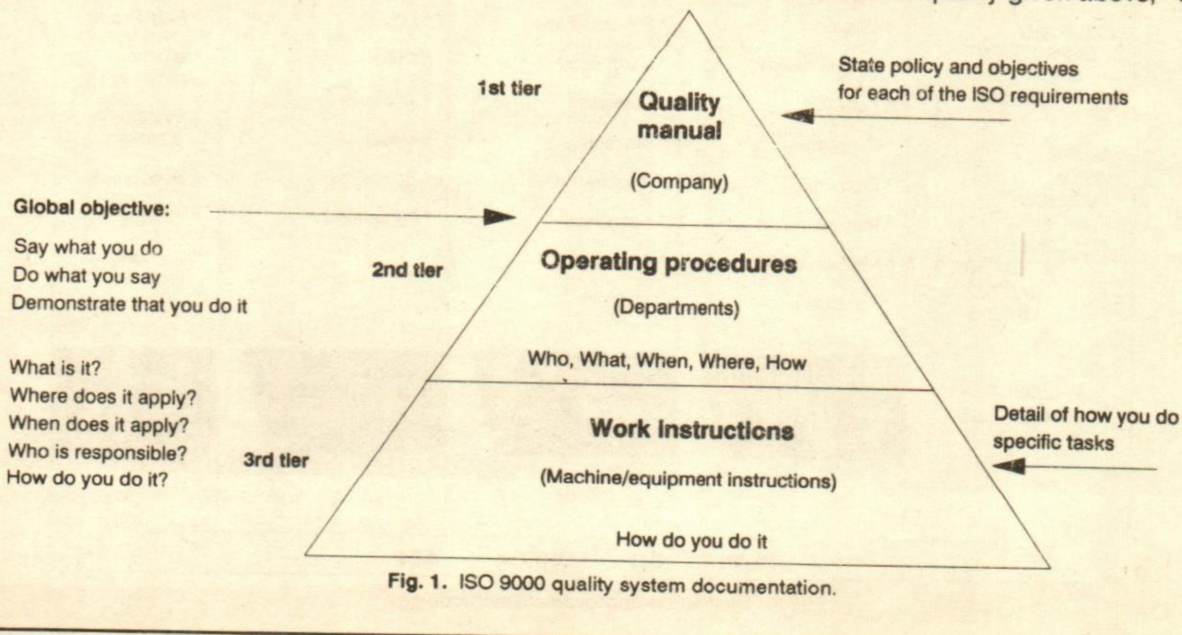

Fig. 1. ISO 9000 quality system documentation.

quality improvement is a systematic method for improving processes to better meet customer needs and expectations."

The overall CI process for a small manufacturer must be straightforward, following the classic "Plan-Do-Check-Act" wheel that Dr. W.E. Deming has proposed:

Plan: Begin by setting goals and planning how to achieve them.

Do: Continue implementing what you have planned.

Check: Gather and analyze data to find out what happened.

Act: On the basis of your analysis of results, act to improve your process.

Based on this basic philosophy, a small American manufacturer of electronic products has teamed up with a local university to implement the CI approach illustrated in Figure 2. The process can be divided into five major blocks:

The first block is the **Planning and Education** (P/E) is conducted by the President and his staff. Each department director is responsible for developing a quality policy and a CI plan and for providing updates for the president. Ideally, directors develop their plan with their own staffs.

The second block is the **Customer/Supplier Analysis** (C/S). The main purpose of C/S analysis is to ensure that organizations have a basis for understanding and for responding to both internal and external customer requirements and expectations. As a result of this analysis, each member of the organization understands how his/her particular function and task relate to meeting customer requirements. One of the first steps of the analysis is to determine the organization's mission statement. In other words, a statement that describes the purpose of existence of the organization. The mission statement, which must be aligned with the company's quality policy, can be defined as the single overriding goal statement for the organization. The supplier is as important to the process as the customer is. If suppliers do not provide the right material at the right time, producers cannot meet their customer's requirements. Adequate and timely communication must exist among suppliers-producers-customers. At the end of the C/S analysis, organizations have developed and documented ongoing procedures and channels of communication with their respective customers and suppliers as well as their requirements, their mission and quality policies. A summary chart of the C/S analysis is depicted in Figure 3.

The purpose of the third block, **Process Flow Analysis** (PFA) is to document all the activities that take place in the business process, so that non-value added steps and bottlenecks can be identified and then eliminated. This helps organizations become more effi-

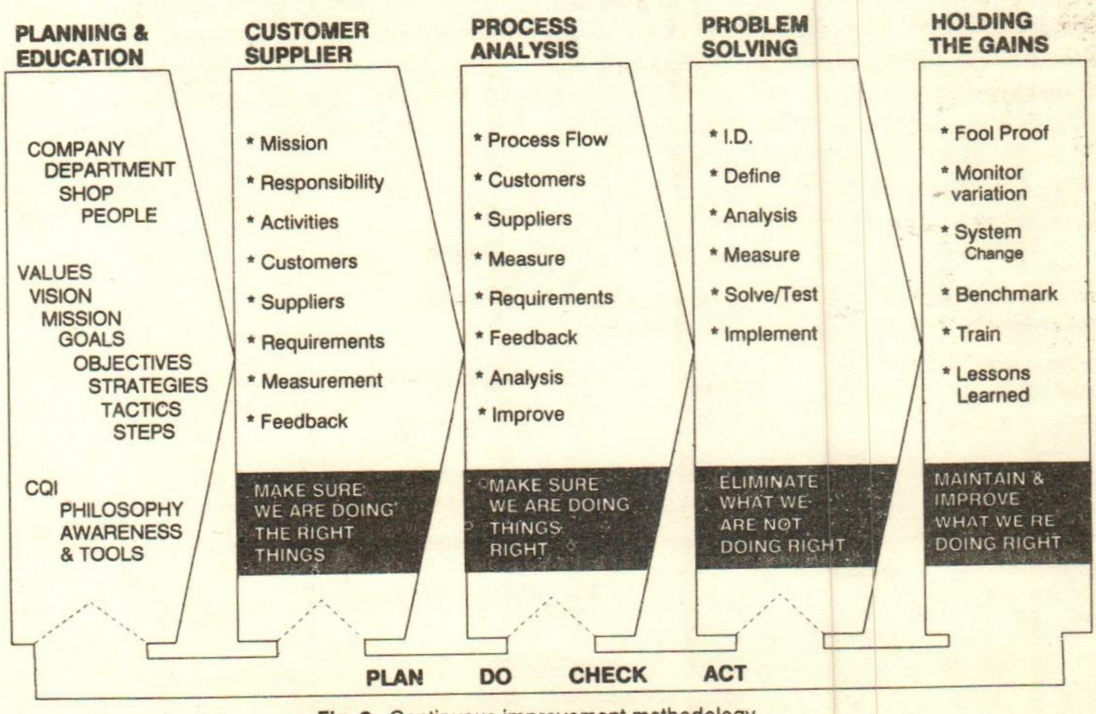

Fig. 2. Continuous improvement methodology.

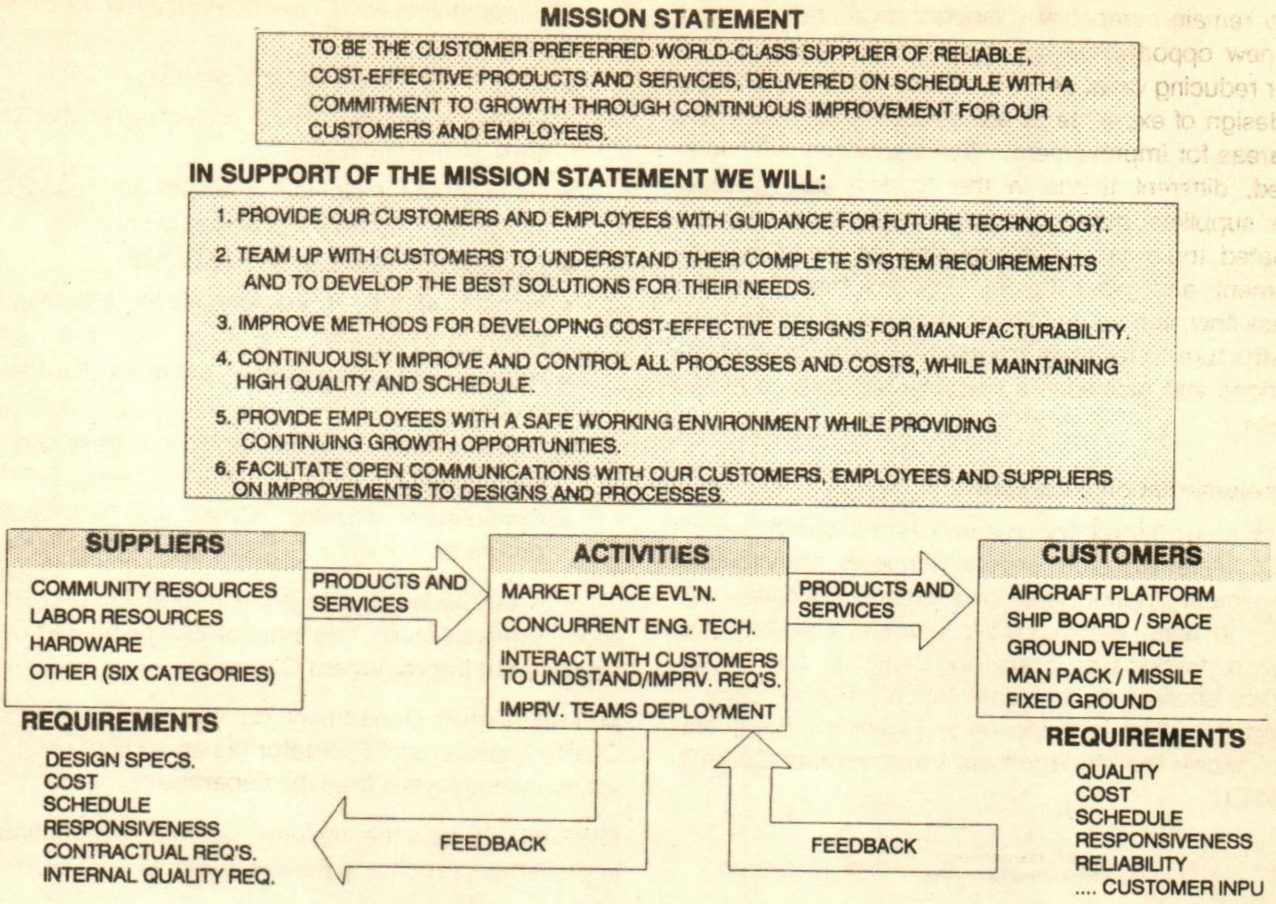

Fig. 3. Summary chart of C/S analysis.

cient. PFA starts by forming teams that involve the experts, i.e. the employees. After the boundaries of the process are set, all activities are documented by using appropriate flowcharting symbols. Organizations compile diagramed and documented flowcharts that are used to isolate problem areas, identify non-value added steps, analyze C/S relationships, identify control and measurement points, and evaluate process efficiency among other things.

The purpose of the fourth block **Problem Analysis and Improvements** (PA&I) is to identify and to eliminate non-value-added activities within the business process, in order to increase quality and capability, and to better meet customer requirements. Dr. Juran's statement that "all improvement takes place project-by-project and in no other way", leads manufacturers with scarce resources. PA&I forces a company to look at all processes, whether in the factory or in office environments, as a sequence of activities or events that have measurable outputs. PA&I then, can be conducted as a step-by-step methodology to improve each element of the process. By using the flowchart analysis, problems and non-conforming characteristics are identified and prioritized. A thorough investigation takes place to determine the root cause so that "real" improvement is made instead of temporary fixes. The problem analysis continues with the collection and analysis of measurable data. Solutions are then generated and prioritized to ensure that the best option is chosen for implementation. PA&I concludes with the evaluation and control step which determines whether real gains have been obtained.

The fifth block, **Holding The Gains**, must not be taken for granted. Many things, such as equipment deterioration and breakdown, material shortages and deficiencies, human error and backsliding, can weaken the gains realized by the changes made in the process. Faced with this possibility, good managers and team members do not just walk away once the "best" solution has been implemented. They provide a systematic means for holding the gains. This fundamental step of the continuous improvement process requires that the changes be monitored by the use of quantitative or qualitative data Statistical process control charts are of paramount benefit to carry out this step.

To remain competitive, though, organizations must seek new opportunities to improve their processes by further reducing variation. Correlation studies and statistical design of experiments are effective tools to identify new areas for improvement. When solutions are implemented, different things in the process can change. Some suppliers may go away, some tasks may be eliminated, the organization's mission may need revision, equipment and plant layout changes may vary the process flow, and so on. These changes create the need of a structure to facilitate the continuous revision of the definitions and procedures documented early in the CI process.

CI Implementation Structure

For a successful documentation of a quality system and CI implementation, several elements are required: management support and involvement, education and training in team work, positive attitude, voluntary participation, tracking of costs and benefits, and an appropriate strategy for implementation. The structure to support this effort is illustrated in Figure 4. The overall coordinator is the **Management Improvement Committee** (MIC):

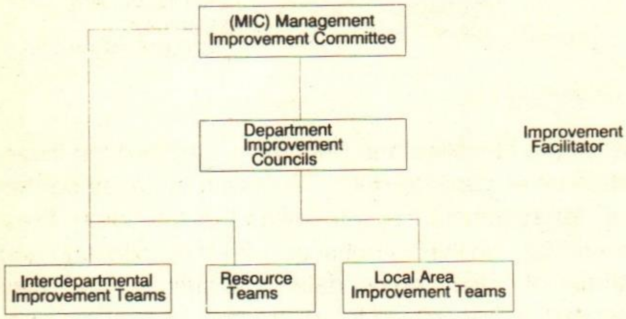

Fig. 4. Implementation structure.

MEMBERSHIP: The president of the company, his/her immediate staff, and the Quality Improvement Facilitator (as an advisor only).

MISSION: To guide the Continuous Improvement (CI) Process, to monitor the implementation of the CI process company-wide, and to assist and to support CI implementation in all departments.

ACCOUNTABILITIES

- Conduct an assessment of company quality level.
- Develop and communicate the vision, quality policy and mission of the company.
- Oversee implementation/documentation of quality systems.
- Recommend and monitor education in CI concepts.
- Recommend improvement projects.
- Identify interdepartmental projects and charter interdepartmental teams.
- Develop and implement a reward and recognition system for improvement accomplishments.
- Develop and maintain annual CI plan.
- Monitor status of company-level improvement teams and projects.
- Review and recommend changes to the CI process.
- Communicate results and progress to all employees.
- Consolidate Quality, Cost and Productivity programs.

It is also necessaryy to provide direction and advice at departmental level. This function can be fulfilled by the **Department Improvement Councils**:

MEMBERSHIP: Department director and his/her staff, Quality Improvement Facilitator (as an advisor only), and voluntary employees from the department.

MISSION: To lead the implementation of the Continuous Improvement Process in the department.

ACCOUNTABILITIES

- Lead department's assessment and customer/supplier analysis.
- Facilitate documentation of quality systems.
- Identify and lead improvement projects.
- Assign local area improvement teams membership.
- Coordinate resource teams assistance.
- Identify and provide means for CI training of team members.
- Report progress to MIC.
- Maintain the department's improvement plan.

The working teams: Interdepartmental teams, local area improvement teams, and the resource teams, are the backbone of the CI process and proper documentation. Each of them has specific functions depending on the type of project being worked. Participation in these teams must be voluntary. Those whose functions are affected by the problem under analysis, those who have the skills, knowledge and experience to contribute to a solution, those who have the responsibility to implement a solution, and those who can facilitate the acquisition of needed resources should participate. □

nplementation of JIT in Indian :nvironment: A Delphi Study

rem Vrat, Saurabh Mittal & Kavi Tyagi

his paper presents the results of a Delphi study con- ucted to examine the applicability of JIT concepts in dian industrial environment. Basic characteristics of T are identified and analytical hierarchy process (AHP) employed to construct the hierarchy and give relative ights to these factors. Opinions of experts are struc- red using Delphi Technique and blended with eightages obtained through AHP to develop the Indian T index and the Indian JIT profile. Major bottlenecks in e implementation of JIT in the Indian environment are entified and priorized so that steps can initiated to fully nefit from JIT policy in Indian environment.

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Despite the world wide attention the concept of Just-in-Time (JIT) has received, it is not yet fully understood and the implications of operating environment required to implement JIT are not fully appreciated. Many a time JIT is taken to be a combination of techniques e.g. *kanban*, group technology, set-up time reduction, supplier programmes etc. In fact JIT is not just a battery of techniques but a grand manufacturing philosophy. It is a concept involving methods, techniques and philosophy operating in a conducive work environment and hence must be understood in a holistic sense. The major objective of JIT philosophy is to eliminate waste – not only the conventional form of waste such as scrap, rework and equipment downtime, but also excess lead-time, over-production and poor space utilisation. The basic principle of JIT production is to produce at each manufacturing stage only the necessary products at the necessary time in the necessary quantity with minimum possible inventory to hold the successive manufacturing stages together. It provides a smoother production flow with the goal to achieve a single unit lot size. An organisation cannot adopt JIT in isolation of its environment – both inner and outer. Hence it is important to identify the environmental parameters relevant for the success of JIT program.

JIT is not just a battery of techniques but a manufacturing philosophy and hence must be understood in a holistic sense.

JIT as a philosophy has apparently worked well in Japanese manufacturing context but its applicability in other operating cultures needs to be investigated.

A comparison of Japanese and Indian Situation

JIT has been developed and implemented in Japan. The system of production and quality management that the Japanese have developed has deep cultural and national roots. Hence a comparison of Japanese and Indian industries will help examining the applicability of JIT in Indian environment and also identify the possible problem areas and steps to be taken to tackle those problems. Table 1 summarizes the various attributes relevant to production systems in Japanese and Indian industries which demonstrate the differences in the two operating environments quite clearly.

Design of the Study

In this paper the attributes of JIT have been constructed by developing the four level hierarchy structure shown in Fig. 1 (Mittal & Kavi, 1992). Analytical Hierarchy Process (AHP) was employed to obtain weightages to the JIT characteristics identified. AHP is a very powerful yet simple technique to develop criteria weights and ranking of JIT characteristics in an integrated framework. Delphi technique 'successive rounds of a structured questionnaire' is dovetailed with AHP to obtain the JIT profile of Indian industries.

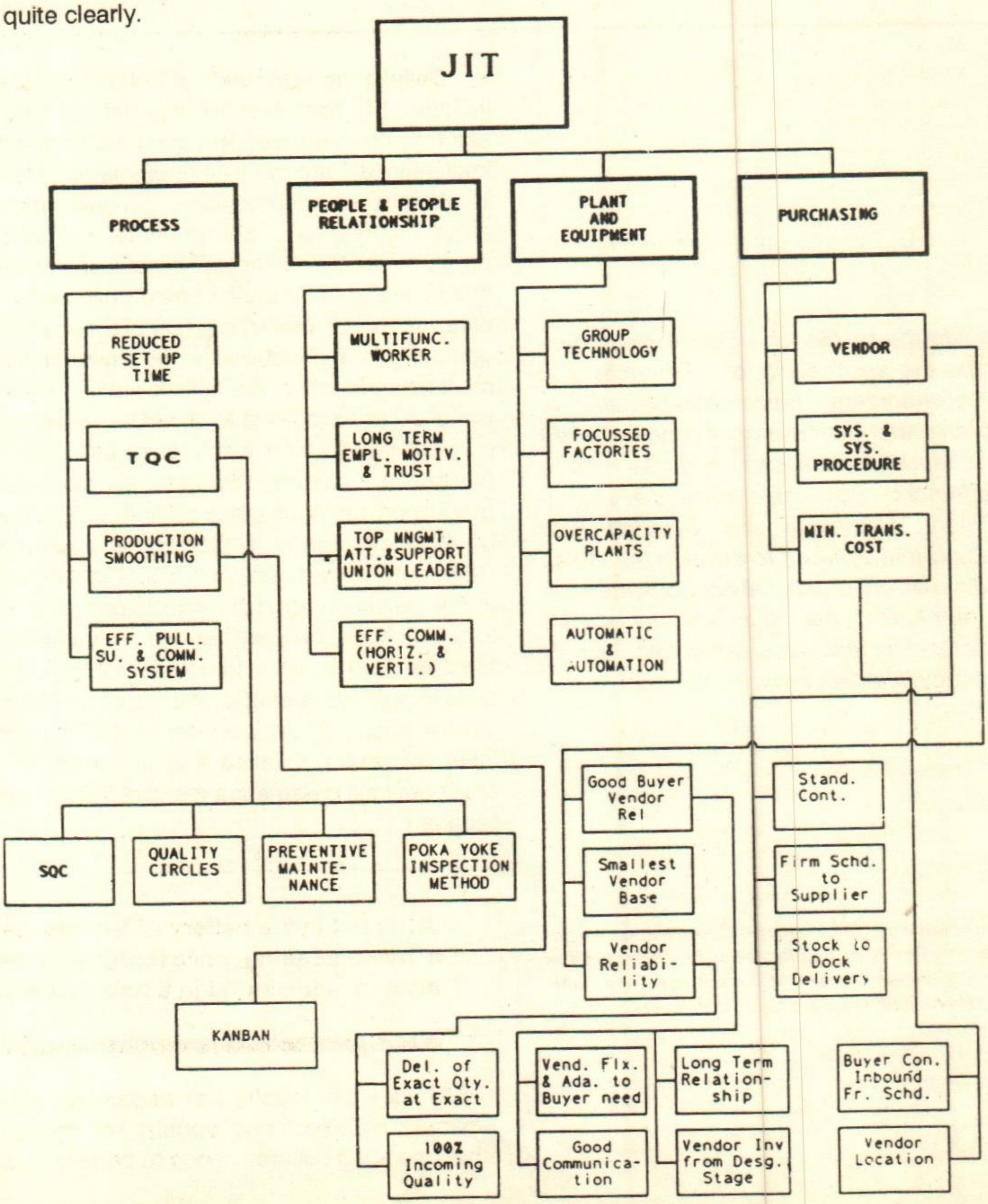

Fig. 1. Overall analytic hierarchy structure for JIT.

Table 1: Comparison of Attributes in Japanese and Indian Industries

Category		Japanese Industry	Indian Industry
1. People	a.	Japanese Workers	Indian Workers
		Cooperation, dedication, harmony & group-thinking decision process.	"Every man for himself" thinking
		Takes pride in his company, high level of motivation	Usually does not identify himself with the company, comparative lack of motivation
		High Literacy	Literacy low
		Multi-functional Workers	Specialized workers
	b.	Enterprise Union (Japan is a homogeneous society)	Interaction between the people at various levels
2. Plants		High Level of Automation; CAD/CAM, robotics used	Very less automation; CAD/CAM, robotics largely absent
		Group Technology present	Group Technology absent
		Autonomous Machining, 100% inspection used	These techniques absent
		Lighted displays to highlight trouble spots are used	Not used
		Companies have their own tool makers to build machines	Machines bought from outside usually on the basis of what is available;
		Seiri, Seiketsu & *Seiten* (orderliness, cleanliness & arrangement practised)	Comparatively untidy & disorganized.
3. Quality Control		Quality at the source, defect prevention	Statistical sampling after lot has been produced, defect detection
		Workers & Foremen have primary responsibility for quality	Quality is the responsibility of Quality Control Department
		100% Quality present	Absent
4. Production Management		KANBAN (pull system)	MRP (push system)
		Preventive maintenance	100% Preventive maintenance absent
		Production line slows up for quality problems, speed up when quality is right	Production line runs at fixed rate; quality problems are sent off line
5. Product & its Values		Customer oriented product; provides real value	R & D lacking; Product designs depend upon what is available rather than what the customer demands
		Belief in long term gains, low profit margin	Strive for shorter term gains.

Ranking of JIT Characteristics by AHP

AHP is based on three stages of problem solving– decomposition, comparative judgement and synthesis of priorities. The complex problems of giving weightages to JIT characteristics were decomposed into a hierarchical structure. The primary indicators of JIT philosophy include plant and equipment, people to people relationship, processes and purchasing as shown in Fig. 1. Pariwise comparisons of characteristics at each levels were done on a 1-9 point scale, 1 reflecting equal weightage and 9 reflecting absolute differences of benefits of the characteristics to weightages. After the pairwise comparison, calculation of principal matrices was done and consistency ratios obtained. Table 2 summarises the results of AHP in developing relative weightages to various JIT characteristics. Figure 2 shows it diagrammatically.

Table 2: Relative Weightage to JIT Characteristics using AHP

	JIT Characteristics	Weightage
a.	Group Technology	0.07763
b.	Automation & Autonomation	0.03293
c.	Overcapacity Plants	0.02048
d.	Focussed Factories	0.00864
e.	Top Management Attitude & Support of Union Leaders	0.04406
f.	Multi-functional Worker	0.02477
g.	Effective Communication	0.00610
h.	Long Term Employment	0.00972
i.	Reduced Set Up Time	0.17001
j.	Poka Yoke	0.13604
k.	SQC	0.02812
l.	Quality Circles	0.01793
m.	Preventive Maintenance	0.08726
n.	KANBAN	0.06579
o.	Stock to Dock Delivery	0.00176
p.	Standard Containers	0.00176
q.	Firm Schedule to Suppliers	0.01198
r.	Vendor Location	0.02169
s.	Buyer Control Over Freight Schedule	0.00723
t.	Delivery	0.04022
u.	Quality	0.08044
v.	Good Communication	0.00572
w.	Long Term Relationship	0.02768
x.	Vendor Flexibility & Adaptivity	0.01775
y.	Inventory From Des. St.	0.00365

Ratings of JIT Characteristics Using Delphi Techniques

Delphi technique attempts to make effective use of informed intuitive judgement. It used the opinion of ex-

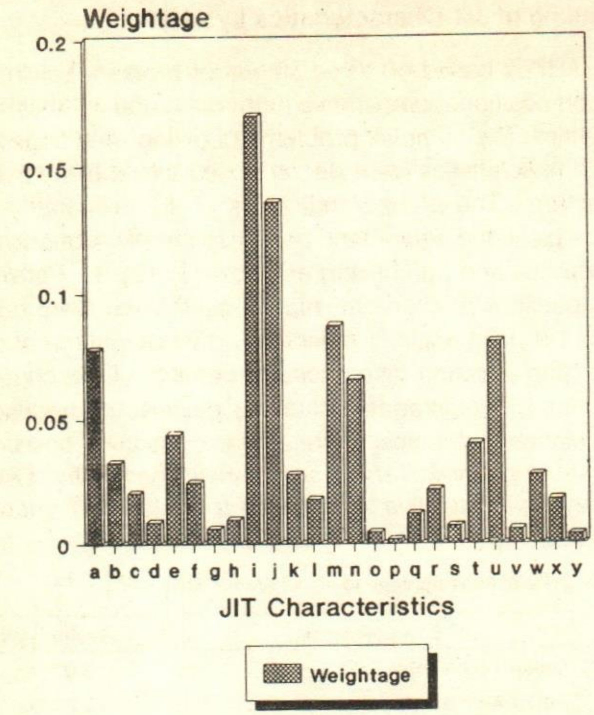

Fig. 2 Bar chart showing weightage

perts in successive rounds of questionnaires in a structured but anonymous manner with feedbacks to experts after each round of questionnaire (Sohal et al, 1989). Selection of experts is the first step and a strategic step in the Delphi technique. For the purpose of this study, efforts were made to choose experts from a wide range of fields with intimate knowledge of the Indian industry as well as familiarity with the concepts of JIT philosophy. A large number of experts were chosen from companies trying to implement JIT or some of its techniques in India.

In the first round of questionnaire, the experts were asked to rate the JIT characteristics on a scale of 0-40 depending upon their applicability to the current Indian production environment. This scale represents the difficulty of implementing a JIT characteristic in India. If according to an expert, a characteristic was more difficult to implement, then it had to be given lower rating. Part B of the questionnaire asked the experts to predict the number of years in which JIT would be applicable in India. The first round of questionnaire was distributed to sixty eight experts. Forty six experts responded. The average IQR (inter quartile range) was approximately nine with seventeen characteristics having IQR's of 10 or more, maximum IQR was 13 for stock to dock delivery, while the minimum IQR was 2 for 'Quality Circles'. Variation in the medians was surprisingly small. All the medians lay in the range 20-32 giving a fairly good initial estimate of expert opinion about applicability of JIT in India. This corresponds to a view that JIT could not be implemented India at present but could be implemented in future w difficulty. The responses to part B of the questionna confirmed this view. The median of the number of yea in which JIT could be applicable in India was 10 years a. the IQR was 8-15 years.

This corresponds to a view that JIT could not be implemented in India at present but could be implemented in future with difficulty.

The second questionnaire contained the summary the results of the first round and the expert rating in roun 1. In part B the experts were asked to rate the probabilit of JIT being relevant to the Indian situation in future. Th second round was given to thirty four experts as som had expressed desire to opt out in the round 1 itself. experts responded to this round. Variations in rating decreased significantly.

In the third round experts were given a concise sum mary and reasons presented in support of extreme po tions. They were then asked to revise their second-rou responses. In all, 18 experts responded to the thi round. The variation in their ratings decreased furth with the average IQR of ratings dropped to 3.5. Part B the third round showed no major change with both t medians and IQR's remaining nearly the same as in th second round. A summary of the third round response given in table 3.

The responses from the three rounds were plotted graphical form for each attribute and a very good conv gence was noted after the third round. The respons from part B of the questionnaire indicate that JIT cann be applied in Indian context right now but the experts a optimistic that JIT will be applicable in future, the high probability being in next 10-20 years.

Development of JIT Index for Indian Context

The weightages obtained through AHP and t results of third round of Delphi were integrated as follo

Weighted rating of characteristic $= W_i \times R_i$

where W_i = Weightage of ith characteristic

R_i = Rating of ith characteristic

The bottlenecks were identified as $(40.W_i - W_i.R_i)$ ith characteristic. The results are shown in table 4.

Table 3: Summary of Third Round of Delphi Study

PART A

	JIT Characteristics	Median	IQR
a.	Group Technology	31	20-31
b.	Automation & Autonomation	22	21-22
c.	Overcapacity Plants	27	24-30
d.	Focussed Factories	20	20-21
e.	Top Management Attitude & Support of Union Leaders	25	22-30
f.	Multi-functional Worker	25	24-31
g.	Effective Communication	26	22-29
h.	Long Term Employment	24	22-25
i.	Reduced Set Up Time	25	25-30
j.	Poka Yoke	20	18-20
k.	SQC	35	32-34
l.	Quality Circles	31	31-31
m.	Preventive Maintenance	31	31-35
n.	KANBAN	21	20-21
o.	Stock to Dock Delivery	15	15-20
p.	Standard Containers	25	21-25
q.	Firm Schedule to Suppliers	25	24-28
r.	Vendor Location	23	22-25
s.	Buyer Control Over Freight Schedule	20	20-21
t.	Delivery	20	19-20
u.	Quality	20	19-21
v.	Good Communication	30	25-30
w.	Long Term Relationship	25	24-27
x.	Vendor Flexibility & Adaptivity	25	22-26
y.	Inventory From Des. St.	25	23-30

PART B

Time period	Median	IQR
Applicable Now	2%	0-10%
Next 0-5 Years	10%	10-20%
Next 5-10 Years	20%	10-30%
Next 10-15 Years	25%	20-25%
Next 15-20 Years	25%	10-30%
After 20 Years	5%	3-20%
Never	0%	0-10%

Table 4: Results Obtained by Integrating Delphi with AHP

	JIT Characteristics	W_i	R_i	$W_i \times R_i$	$40 \times R_i - W_i \times R_i$
a.	Group Technology	0.07763	31	2.40653	0.69867
b.	Automation & Autonomation	0.03293	22	0.72446	0.59274
c.	Overcapacity Plants	0.02048	27	0.55296	0.26624
d.	Focussed Factories	0.00864	20	0.17280	0.17280
e.	Top Management Attitude & Support of Union Leaders	0.04406	25	1.10150	0.66090
f.	Multi-functional Worker	0.02477	25	0.61925	0.37155
g.	Effective Communication	0.00610	26	0.15860	0.08540
h.	Long Term Employment	0.00972	24	0.23328	0.15552
i.	Reduced Set Up Time	0.17001	25	4.25025	2.55015
j.	Poka Yoke	0.13604	20	2.72080	2.72080
k.	SQC	0.02812	33	0.92796	0.19684
l.	Quality Circles	0.01793	31	0.55583	0.16137
m.	Preventive Maintenance	0.08726	31	2.70506	0.78534
n	KANBAN	0.06579	21	1.38159	1.25001
o.	Stock to Dock Delivery	0.00460	15	0.06900	0.11500
p.	Standard Containers	0.00176	25	0.04400	0.02640
q	Firm Schedule to Suppliers	0.01198	25	0.29950	0.17970
r.	Vendor Location	0.02169	23	0.49887	0.36873
s.	Buyer Control Over Freight Schedule	0.00723	20	0.14460	0.14460
t.	Delivery	0.04022	20	0.80440	0.80440
u.	Quality	0.08044	20	1.60880	1.60880
v.	Good Communication	0.00572	30	0.17160	0.05720
w.	Long Term Relationship	0.02768	25	0.69200	0.41520
x.	Vendor Flexibility & Adaptivity	0.01775	25	0.44375	0.26625
y.	Inventory From Des. St.	0.00365	25	0.09125	0.05475

The JIT index was obtained as $\Sigma W_i R_i$ representing the applicability of JIT philosophy to Indian industry on a scale of 40. The current JIT index comes out to be 23.38. This means that though it will be quite difficult, JIT can be applied to Indian situation. The JIT profile of the Indian industrial scene is shown in Fig. 3. This figure compares the Indian JIT profile with the ideal JIT profile, the problem areas in implementation of JIT in India can be easily identified from this graph.

This means that though it will be quite difficult, JIT can be applied to Indian situation.

Identification of Bottlenecks in JIT Implementation

The value of bottlenecks were computed using the gap between ideal and current profile as ($40 W_i - W_i R_i$) for ith attribute. These attributes were prioritized. The various bottlenecks identified are:

- *Poka yoke* inspection method

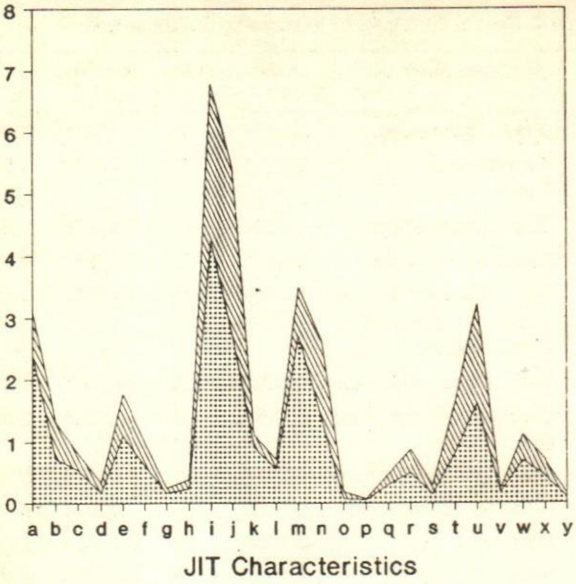

Fig. 3. JIT Profit of the Indian Industry versus Ideal JIT Profile.

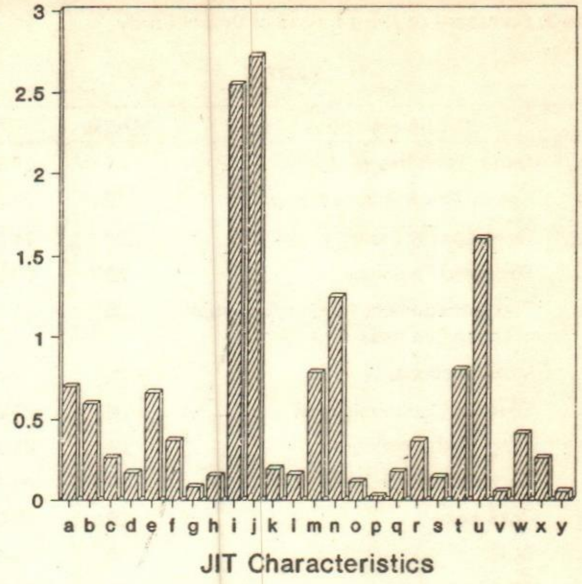

Fig. 4. Bar Chart showing Bottlenecks Values.

- Reduction of set-up times
- 100% incoming quality
- Kanban system
- Delivery (from vendor) of exact quantity on exact time
- Preventive maintenance
- Group technology

Figure 4 shows these bottlenecks graphically. All these bottlenecks can be tackled only with a very serious planned effort. There is a need for overall increase in quality consciousness in the factory. This is necessary for implementing Poka Yoke inspection methods and 100% incoming quality. Worker motivation and literacy need to be increased. These are important for reducing set-up time and introducing Kanban systems. Top management involvement and commitment to JIT is needed. This calls for a drastic change in the working environment and change of attitude in people. This change is difficult but possible. The current emphasis on TQM and ISO 9000 is a possible indicator that the Indian industry is attempting to overcome these bottlenecks.

Worker motivation and literacy need to be increased for reducing set-up time and introducing Kanban systems.

Concluding Remarks

Due to wide differences in the operating environment of Japanese and Indian industries, there is a need to improve the work environment before JIT can be implemented in India. As a result, it may take 10-20 years before JIT can be fully implemented in Indian industries. The current JIT index is 23.38 on a 40 point scale implying that though it is quite difficult JIT implementation is possible. The main characteristics that need to be attended to for JIT implementation in India are Poka Yoke inspection methods, reduced set-up times, 100% incoming quality, Kanban systems and delivery by the vendor of exact quantity on exact time as these are at present the main bottlenecks.

Acknowledgement

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References

Mittal, Saurabh & Tyagi, Kavi, "Applicability of Just-in-Time Philosophy to the Indian Industry". B. Tech Project in Manufacturing Science & Engineering, IIT, Delhi, May 1992.

Schonberger, R.J., "Japanese Manufacturing Techniques-Nine Hidden Lessons in Simplicity", The Free Press, New York, 1982.

Sohal, A.S. Keller, A.Z. & Fouad, R.H., "A Review of Literature Relating to JIT", International Journal of Operations and Production Management, Vol. 19, No. 3, 1989.

Role of Maintenance in Manufacturing Management

Xiao-Gao Liu, Viliam Makis & Andrew K.S. Jardine

As part of the production process, maintenance programs can play a much more active role in the management of manufacturing systems. They are not just some cost burdens. Properly designed maintenance programs can enhance the overall system performance by reducing the need for inventory, smoothing production flows and/or improving product quality. This aspect is becoming increasingly more important as manufacturing management places more emphasis on service related performance of manufacturing systems. This paper discusses some models for understanding this role of maintenance.

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We view maintenance programs as part of the production process. Although this view seems quite natural and unquestionable, an important implication is often overlooked: i.e., maintenance policies must be studied considering how they will affect the overall performance of manufacturing systems. As part of the production process, maintenance programs must not only be organized to be more efficient and effective for specific maintenance tasks, but also be balanced with production. A balanced maintenance program implies that it is designed to ensure the optimality of the overall performance in stead of the optimality of the maintenance program itself. This role of maintenance can be seen more clearly if one notices that, e.g., many systems carry safety stocks to absorb the impact of equipment breakdowns, while such an impact may be reduced and controlled by better planned maintenance programs as well. As lower inventory levels and a greater emphasis upon flow-oriented manufacturing systems and automated equipment with increased complexity are becoming more prevalent in the manufacturing sector, this role of maintenance in manufacturing management becomes increasingly important. This trend is especially true if one adopts a more general definition of maintenance, allowing it to include not only equipment related maintenance activities but also activities related to training and quality control.

A balanced maintenance program designed to ensure the optimality of the overall performance in stead of the optimality of the maintenance program itself.

Traditional Models

In the past three decades, tremendous effort has been devoted to studying maintenance policies and production control policies. However, as pointed out by Lee and Rosenblatt (1989), a majority of existing results in the literature tend to treat maintenance and production problems as two sets of separate problems. Although it can sometimes simplify the solution of the problems, this separation may limit the application of the results of both areas in real systems. First, production control policies developed without the consideration of the impact of machine breakdowns may not be suitable for systems subject to machine breakdowns. Second, unaware of maintenance programs as means to improve system performance, production managers who rely only on pure production control methods such as inventory control and scheduling may be limited in their options for combating random interruptions in the production process. Third, maintenance policies developed without a direct link to the overall performance of manufacturing systems may have used untrue assumptions. For example, many maintenance models assume that the system under consideration is fully loaded or is in use all the time. However, machines in real manufacturing systems are all the time. Since an idle machine is less likely to break down, the maintenance program based on the full load assumption is likely to provide over-maintenance. As another example, many maintenance models use availability or the cost of downtime as the objective or constraint of the associated optimization problem. However, if the system is not fully loaded, availability may not reflect the true requirement of the system for maintenance, since an available idle machine cannot make profits anyway. Similarly, if a machine is idle, whether it is up or down at the moment will actually make no difference in terms of "downtime costs" (revenue losses). Downtime cost is either not accurate or very difficult to measure in many situations, and therefore must be used cautiously.

These observations further suggest the need for studying models of joint maintenance and production problems. Valdez-Flores and Feldman (1989), Cho and Parlar (1991), Pintelon and Gelders (1992) and Dekker (1992) supply recent surveys of maintenance optimization models; and Silver and Peterson (1985) and Buzacott and Shanthikumar (1993) provide surveys and recent results of production control models, in this context.

Maintenance and the EMQ Model

Recently, several authors discussed how to incorporate maintenance decisions into the classical Economic Manufacturing Quantity (EMQ) model. Th EMQ model, perhaps the simplest production contr model, assumes that demands for an item arrive to th system continuously at a constant rate of D per unit tim and a machine with a production rate of P (> D) items pe unit time is set up from time to time to produce the item to satisfy the demand; the issue is how many items shoul be produced in each production run (cycle) in order t minimize the total cost, a sum of the setup cost at $K pe production run and the inventory holding cost at $h pe item per unit time (Silver and Peterson 1985,). To generalize this model to include maintenance features, we ca consider that the machine in the system may randomly g "out of control" (fail, break down) from time to time, which means that either the machine cannot produce at all or it will produce some defective items that may need rework or must be scrapped. Two models based on these observations are reviewed with the following two key assumptions:

Assumption 1 (The operation dependent failure) The machine can fail only when it is in use.

Assumption 2 (The exponential up time) The up time (time to failure) of the machine is an exponentially distributed random variable with mean 1/a; the successive up times are independent and identically distributed.

The assumption of operation dependent failures is usually true in manufacturing systems. It can also be argued that the exponential up time is an acceptable assumption for manufacturing systems if we notice that a machine is often complex equipment consisting of many components, the failure of any of which may cause the malfunction (failure) of the machine, and as a result, the time between machine failures is likely to follow the exponential distribution according to renewal theory (Koenigsberg 1959). This observation provides a reason why preventive maintenance can still be *relevant* under the exponential up time assumption. Since each individual component may exhibit wearout characteristics (have an increasing failure rate), maintenance will reduce the occurrence of its failures. This will in turn reduce the total number of the failures of the machine. As implication of this observation is that preventive maintenance can also increase the mean up time of a machine with exponential up time (Jardine 1973). In order to see the effect of preventive maintenance under the exponential up time assumption we may also view this assumption simply as a useful approximation for using the first moment information of the non-exponential up time. [For a study of a real system that supports the two assumptions, see Buzacot and Hanifin (1978)].

A system with restoration cost dependent on detection delay

The first model considered here is from Lee and Rosenblatt (1989). This model extends the EMQ model by introducing the following assumptions.

- When the machine is in use, it can be in one of the two states: "in-control" (producing items of acceptable quality) and "out-of-control" (producing some defects).
- When a production cycle starts, the machine is in the "in-control" state, and after producing for some period of time, it may shift to the "out-of-control" state. The up time follows the exponential distribution with mean 1/a.
- Once the machine is "out-of-control", it stays in that state until a scheduled inspection followed by a restoration takes place. Each scheduled inspection costs $\$\nu$. The cost of a restoration depends on the detection delay, τ, the elapsed time since the shift of the machine from "in-control" to "out-of-control". This cost is denoted by $R(\tau)$. Inspection and restoration are instantaneous.
- An inspection schedule for a production cycle of length T time units is given by $0 < T_1 < ... < T_n = T$ where $T_{i+1} - T_i$ means the time between inspections i and i + 1.
- The percentage of defective items produced in the "out-of-control" state is α. Each defective item is repaired with a cost of \$s per item. Repairs are instantaneous.

- The system allows backorders. The maximum backorder levels permitted in each production cycle is B. The cost of backorder is $\$\nu$ per item per unit time.

- The objective is to find the optimal T*, B* and n* that minimize the total cost.

The assumptions of instantaneous inspection, restoration and repairs greatly simplify the model: the sample path of the on-hand inventory of the model is similar to that of the EMQ model since the machine breakdowns have no effect on the quantity of the inventory. As a result, the average inventory holding and backorder cost per unit time can easily be found as

$$\frac{h\,[T\,(P - D)\,B]^2 + \pi B^2}{2T\,(P - D)} \qquad (1)$$

To obtain the average cost for defective items, let t be the length of the up time of the machine in the time interval (T_i, T_{i+1}). Thus, max $(T_{i+1} - T_i - t, 0)$ is the time in which the machine is "out-of-control" in (T_i, T_{i+1}). By the exponential up time assumption, we have the average number of defective items produced in (T_i, T_{i+1}) as

$$\int_0 T_{i+1} - T_i \qquad \alpha P\,(T_{i+1} - T_i - t)\,ae^{-at}\,dt$$

$$= \alpha P \left(T_{i+1} - T_i + \frac{1}{a}e^{-a\,(T_{i+1} - T_i)} - \frac{1}{a}\right).$$

Thus, the average cost for defective items produced in a production cycle is

$$s\alpha P \left(T + \frac{1}{a}\sum_{i=1}^{n} e^{-a\,(T_{i+1} - T_i)} - \frac{1}{a}\right). \qquad (2)$$

Similarly, using $\tau = T_{i+1} - T_i - t$, the average cost for restoration in a production cycle can be written as

$$\sum_{i=1}^{n} \int_0^{T_{i+1} - T_i} aR(\tau)\,e^{-a\,(T_{i+1} - T_i - \tau)}\,d\tau\,. \qquad (3)$$

There are, on average, D/PT cycles per unit time, and in each cycle, there are n scheduled inspections. Combining these with (1), (2) and (3), we have the total cost per unit time,

$$TC = \frac{(K + n\nu)\,D}{PT} + \frac{h\,[T\,(P - D)\,B]^2 + \pi B^2}{2T\,(P - D)}$$
$$+ \frac{D}{PT}\left[s\alpha P \times \left(T + \frac{1}{a}\sum_{i=1}^{n} e^{-a\,(T_{i+1} - T_i)} - \frac{1}{a}\right)\right.$$
$$\left. + \sum_{i=1}^{n} \int_0^{T_{i+1} - T_i} aR\,(\tau)\,e^{-a\,(T_{i+1} - T_i - \tau)}\,d\tau\right]. \qquad (4)$$

To solve Eq. (4), Lee and Rosenblatt (1989) considered three forms of $R(\tau) : R(\tau)$ is constant and independent of τ; $R(\tau) = p + q\tau$ $(p, q > 0)$; $R(\tau) = p + q[1 - e^{-\omega\tau}]$ $(p, q\omega > 0)$. They further established sufficient conditions under which the optimal inspection schedule is of equal intervals, i.e., $T_{i+1} - T_i = T/n$ for all i. Using these results, they developed an efficient approximation procedure to obtain T^*, B^*, n^* jointly. The main conclusion from their study is that the generalized EMQ model will reduce the cost of the classical EMQ model. Their numerical examples suggest that the improvement is in the range of 5 to 6 per cent.

Since the cost components for defective items and the detection delay are both functions of the failure rate a, an interesting extension of the above model could be to consider the effect of preventive maintenance in the model: such maintenance will reduce a at a certain cost. Another direction for improving the model is to consider how to incorporate more realistic finite repair, inspection and restoration times into the model, which, of course, may make the model more complex.

A system with finite repair time and safety stocks

Next, we consider a generalized EMQ model developed by Groenevelt, Pintelon and Seidmann (1992), which assumes finite repair time along with the effect of safety stocks. To model was used by these authors to study the tradeoffs among preventive maintenance, corrective maintenance and safety stocks for reducing the effect of machine breakdowns. The main assumptions of the model are as follows.

(a) The machine may break down and be under repair during a production run. The repair of machine takes a finite time, R, which is a random variable with mean r. The cost for repairs is $c per unit time.

(b) The machine needs a fixed setup time, t_s, each time after being idle or being repaired. During its idle time, the machine is under preventive maintenance, which takes t_m time units to complete. The cost for preventive maintenance is $p per production run.

(c) The inventory of the system is divided into two parts: the regular running stock and the safety stock. During each production run, a fraction, β, of the items produced is diverted into the safety stock, and the rest of items produced are put into the running stock.

(d) The running stock is used only to satisfy the demand when the machine is up or idle, and the safety stock is used only to satisfy the demand when the machine is under repair. If during a repair period, the safety stock is empty, the demand is lost, and this can happen even when the running stock is not depleted.

(e) The objective is to find optimal Q (lot size or manufacturing quantity) that minimize the total cost subject to a target service level α_β (desired fraction of total demand satisfied).

As can be seen, the most restrictive of these assumptions is (d). Although it may be unrealistic, this assumption allows the lot size decision and the safety stock decision to be separated; as a result, the solution of the model is greatly simplified. To see this, observe the sample path of the on-hand inventory in the running stock. During the production period, the curve will steadily increase at a rate (slope) of $p\ (1 - \beta) - D\ (> 0)$ if the machine is up, and it will be level for an average of $r + t_s$ time units whenever there is a machine breakdown since under the assumption, the demand during a machine breakdown is satisfied by the safety stock or lost. This observation suggests that the total amount available in the running stock at the end of the production period is not affected by the machine breakdowns. Thus, the sample path is very similar to that of the EMQ model.

To derive the total cost function, we need the mean production cycle time (production time plus idle time). Observe that the pure production time to complete Q items is Q/P. During this period, an average of aQ/P machine breakdowns will occur, and each breakdown will stop the machine for an average of $r + t_s$ time units. Thus, the mean total time for the machine to complete Q is $Q/P + aQ/P(r + t_s)$. Since the total available inventory in the running stock at the end of the production period is the same as that of the system without machine breakdowns, with the rate of inventory accumulation in the running stock as $P(1 - \beta) - D$ and the pure production time as Q/P, we have this total available inventory as $Q(1 - \beta) - DQ/P$. The time for demand to consume this amount (the ideal time) is $Q/D(1 - \beta) - Q/P$. As a result, we have

$$E[\text{ cycle length}] = \frac{Q}{D}(1-\beta) + \frac{aQ}{P}(r + t_s). \quad (5)$$

Using (5), the achieved service level can be obtained,

$$\alpha_\beta = \frac{\text{production per cycle}}{\text{E[demand per cycle]}} = \frac{P/D}{(1-\beta)(P/D) + a(r + t_s)} \quad (6)$$

Observe that α_β is not affected by Q, and β can be determined for given α_β using this expression along with $P(1 - \beta) > D$. These observations suggest that the lot size decision and the safety stock decision are indeed independent of each other. Thus, the total cost for the optimal Q does not need to include the cost component associated with the safety stock.

The total cost per unit time are the sum of the following cost components:

(i) the setup cost,

$$\text{SUC} = \frac{K + K\,a(Q/P)}{E[\text{cycle length}]}; \quad (7)$$

(ii) the preventive maintenance cost,

$$\text{PMC} = \frac{p}{E[\text{cycle length}]}; \quad (8)$$

(iii) the corrective maintenance (repair) cost,

$$\text{CMC} = \frac{ca(Q/P)\,r}{E[\text{cycle length}]}; \quad (9)$$

(iv) the running stock holding cost,

$$\text{RSHC} = \frac{hE(I)}{E(\text{cycle length})}, \tag{10}$$

where

$$E[I] = \frac{1}{2}\left[Q(1-\beta) - \frac{DQ}{P}\right]\frac{Q(1-\beta)}{D} + \frac{1}{2}a\left(\frac{Q}{P}\right)^2 [P(1-\beta) - D](r + t_s). \tag{11}$$

To see (10), note that $E[I]$ is the area under the running stock curve (average inventory) in a production cycle, which is composed of two parts: one related to the area of the system without machine breakdowns, the first term in (11); the other related to the area due to machine breakdowns, the second term in (11). To calculate the area due to machine breakdowns, suppose that there are n breakdowns during Q/P: the first breakdown occurs at S_1 $(0 < S_1 < Q/P)$; the second breakdown occurs at S_2 $(S_1 < S_2 < Q/P)$, and so on. Since during a repair period the inventory curve is level, we have the area corresponding to the first breakdown as $[P(1-\beta) - D]\, E[S_1]\,(r + t_s)$, and the area corresponding to the second breakdown as $[P(1-\beta) - D]\, E[S_2]\,(r + t_s)$, and so on. Thus, the total area for n breakdowns is $E[S_1 + \cdots + S_n | n]\,[P(1-\beta)D]\,(r + t_s)$. Since n follows the Poisson distribution with mean aQ/P, S_i $(i = 1, \ldots, n)$ is uniformly distributed on Q/P (Ross 1983). Using this fact, we can easily see the second term of (11).

It can be verified that the total cost function based on (7)-(10) is a convex function of Q. Thus, the optimal Q can be efficiently obtained for given β under the constraint that $E[\text{cycle length}] => t_m + t_s$.

In contrast to Eq. (10), Groenevelt, Pintelon and Seidmann (1992) had

$$\text{RSHC} = \frac{1}{2}hQ\left(1 - \beta - \frac{D}{P}\right). \tag{12}$$

This expression is obtained using the first term of (11) with the cycle time $Q/P(1 - \beta)$, which is correct for the system without breakdowns, but obviously inconsistent with the above assumptions. Nevertheless, using the total cost function with (12), they found their results consistent with simulation tests which relax Assumption (d) by allowing the demand to be satisfied by both the running stock and the safety stock at any time. Further tests are needed to justify the use of (12).

In order to use the above model for studying the tradeoffs among preventive maintenance, corrective maintenance and safety stocks, Groenevelt, Pintelon and Seidmann (1992) introduced a maintenance budget level concept. For example, the budget level can represent crew training or diagnostic equipment. Thus, the higher the budget level, the smaller the failure rate. They assumed that $1/a$ is a concave function of the budget level measured by $\$b$ per unit time. Further, since the failure rate affects the average safety stock, the holding cost for the safety stock must be considered in making the tradeoffs. They showed that the average safety stock.

$$SS = \alpha_\beta DE[F], \tag{13}$$

where F is the flow time of the $GI/M/1$ queue with a service rate of $\tilde{\mu} = aD/(P\beta)$, and interarrival time $R + t_s$. With these results, they demonstrated that the model can be used to study the interaction among the budget level α_β, Q, D, and r. For example, the optimal budget level and Q will increase as α_β increases; the optimal budget level is less sensitive to changes in D than to changes in r.

Maintenance and Queueing Models

Queueing models have been widely used in modeling manufacturing systems (Buzacott and Shanthikumar 1993). An advantage of these models is that they can easily model both the random behaviour of the production process and the irregularity of demand arrivals over time. (Note that the two aforementioned studies assume no randomness in the demand process.) Few results are available along this line in the open literature although much has been done in modeling unreliable machines of manufacturing systems for performance evaluation (e.g. Dallery and Gershwin 1992).

Produce-to-order and produce-to-stock systems

Consider a standard single queue model, in which customers arrive at a server to receive service; the interarrival time and the service time of a customer are both independent random variables; if there are more than one customer in the system, the customers are served on a first-come-first-serve basis. The simplest case of this model is the M/M/1 queue, in which both the interarrival time and the service time are exponentially distributed with rates λ and μ, respectively. Let $\rho = \lambda/\mu$ and N be the queue length (the total number of customers) in the system. For $\rho < 1$, we have the queue length distribution of the $M/M/1$ queue (see, e.g., Ross 1983, P.155).

$$\Pr\{N = n\} = (1 - \rho)\rho_n, \quad n = 0, 1, \ldots. \tag{14}$$

One of the important applications of this type of queue is to use it for analyzing the so-called produce-to-order manufacturing system, in which each demand (job, customer order) must be processed on an individual basis, and no finished product inventory is held by the system. A key performance measure for the produce-to-order system is the job flow time, F, i.e., the time between the demand arrival and the corresponding job completion. Using the mean job flow time, the manufacturer can provide a due date (the current date plus the mean flow time) to each accepted job. Clearly, the shorter the mean job flow time, the better. Also importantly, a customer would expect that the job is indeed delivered on the due date. Thus, the smaller the variance of the job flow time, the better.

For the M/M/1 queue, the job flow time distribution can be obtained using (14). Let $\widetilde{F}(s) = E[e^{-sF}]$, the Laplace-Stieltjes transform of F, and $\widetilde{S}(s) = \mu/(s + \mu)$, the Laplace-Stieltjes transform of the exponential service time with rate μ. For an arriving job that sees n jobs waiting in the system, its flow time will be the sum of the service times of the n jobs and its own service time under the exponential service time assumption. That is, for given n, $\widetilde{F}(s)\,|_n = [\widetilde{S}(s)]^{n+1}$. Thus,

$$\widetilde{F}(s) = E[e^{-sF}\}] = \sum_{n=0}^{\infty} [\widetilde{S}(s)]^{n+1} (1-\rho)\rho^n$$

$$= \frac{\mu}{s+\mu}(1-\rho) \sum_{n=0}^{\infty} \left[\frac{\mu\rho}{s+\mu}\right]^n$$

$$= \frac{\mu(1-\rho)}{s+\mu(1-\rho)} \tag{15}$$

Clearly, F is exponentially distributed with rate $\mu(1-\rho)$. Thus, $E[F] = 1/[\mu(1-\rho)]$ and the variance of F, $V[F] = 1/[\mu(1-\rho)]^2$. As can be seen, for the $M/M/1$ queue, both $E[F]$ and $V[F]$ are decreasing in μ. Thus, one can obtain the desirable $E[F]$ and $V[F]$ be controlling μ.

Another interesting application of queueing models that receives much attention recently is to use them for studying the so-called produce-to-stock manufacturing system (i.e., the production/inventory system), which typically uses finished product inventory to satisfy the demand. Consider a special single stage produce-to-stock system with a machine and an output store of capacity z (the maximum allowable inventory). The production control mechanism is as follows. If the output store holds z finished items, the machine is turned off. The machine will be turned on again as soon as a customer arrives. Each arriving customer will place a production order to the machine and remove one finished item out of the store. If the store is not empty, the customer will be satisfied and leave the system immediately. If the store is empty, the customer will wait until an item becomes available. The machine will stay on until all the production orders are completed.

Suppose that initially the output store is full, and there is no production order at the machine. Observe that in this case, if there are I (> 0) finished products in the output store, there must be exactly $z - I$ production orders at the machine, and if there is no finished products in the output store, there must be z or more production orders at the machine. The reverse is also true: if there are $z - I$ $(0 < I \leq z)$ production orders at the machine, there must be I items in the output store; if there are z or more production orders at the machine, the output store must be empty. As a result, since the number of production orders at the machine seen by an arriving customer is equivalent to the queue length seen by an arriving customer in a single queue, we can use the solution of the single queue to analyze the produce-to-order system. A useful performance measure for this system is the fill rate, f, the proportion of customer orders satisfied directly by finished products in the output store. Note that an arriving customer can be satisfied immediately if (s)he sees the output store not empty. Using the above relationship between the number in store and the number at machine, we have $f = \sum_{n=0}^{z-1} Pr\{N = n\}$. For the $M/M/1$ queue, using (14), we obtain

$$f = \sum_{n=0}^{z-1} Pr\{N = n\} = 1 - \rho^z. \tag{16}$$

Clearly, from (16), f is increasing in z. As can be seen, f is also increasing in μ. Thus, the desired f may be achieved by controlling μ as well.

Other inventory-related performance measures of the produce-to-stock system can similarly be obtained using the queue solution. With these measure optimization models of the system can be established. From (14), we have the average inventory in the store,

$$E[I] = z - \frac{\rho}{1-\rho}(1-\rho^z), \tag{17}$$

and the average backorder in the system (the average number of customers waiting),

$$E[B] = \frac{\rho^{z+1}}{1-\rho}. \tag{18}$$

The above discussion can be extended to other more mplex produce-to-order and produce-to-stock sys- ns, e.g., the MRP system and the Kanban system. See ızacott and Shanthikumar (1993) and Spearman (1992) · recent results in this direction and Srinivasan and Lee 991) for an application of the above idea to generalizing ə EMQ model based on the $M^X/G/1$ vacation queue.

ıe impact of machine breakdowns

If the machine can breakdown and must take finite ne to be repaired during serving a job, the total time ɔent by the job in the machine can be longer than its ɔrmal service time, and this may interfere with the ser- ce of other jobs. In designing produce-to-order and roduce-to-stock systems, it is important to consider how ıe system performance will be affected by such machine reakdowns and how this impact can be controlled.

In designing produce-to-order and produce-to-stock systems, it is important to consider how the system performance will be affected by machine breakdowns and how this impact can be controlled.

In order to model machine breakdowns, following the liscussion of the previous section, we assume that nachine breakdowns are operation dependent and the nachine has exponential up time. Let S, R and a be espectively the service time, repair time, and the failure ate of the machine. Thus, the total time spent by a job in he machine, S_A, can be expressed as

$$S_A = S + \sum_{n=0}^{N(a,S)} R_n, \tag{19}$$

vhere $N(a, S)$ is the total number of machine breakdowns luring the service time S, which follows the Poisson dis- ribution with mean ax if $S = x$ and R_n is the repair time of he nth breakdown ($R_0 \equiv 0$). Denoting the Laplace- Stieltjes transforms of S_A, S, and R, by $\tilde{S}_A(s)$, $\tilde{S}(s)$, and $\tilde{R}(s)$, respectively, we have,

$$\tilde{S}_A(s) = E[e^{-sS_A}] = \tilde{S}(s + a(1 - \tilde{R}(s))), \tag{20}$$

$$E[S_A] = -\tilde{S}'_A(0) = E[S](1 + aE[R]), \tag{21}$$

$$E[S_A^2] = \tilde{S}''_A(0) = E[S^2](1 + aE[R])^2 + aE[S]E[R^2] \tag{22}$$

see Buzacott and Shanthikumar 1993, P.234). Observe ıat if we can only see the input and output of the machine, the total time spend by a job in the machine is actually what we call the service time of the job. Thus, to model machine breakdowns we can effectively use S_A to replace the actual service time in queueing models. This simple treatment will allow one to use many existing queueing results that originally do not assume machine breakdowns.

As can be seen from (21), the effective service rate of the machine, $\mu_A = 1/E[S_A]$, is decreasing in a. Suppose that we can use the $M/M/1$ queue to describe the system behaviour. From (15) and (16), we see that the mean job flow time is increasing in a, and the fill rate is decreasing in a. That is, these performance measures may be controlled by altering failure rate a. This observation clearly shows the important role of maintenance in manufacturing management. Interestingly, the fill rate case also suggests that by recognizing the role of maintenance, a tradeoff may be made between traditional production control methods (e.g. control z) and maintenance policies (e.g. control a) for improving the system performance (see (16)). Groenevelt, Pintelon and Seidmann (1992) made a similar observation with their generalized EMQ model. One may also observe this potential tradeoff from a model developed by Posner and Berg (1989).

Modeling maintenance effort

Thus in order to develop joint maintenance optimization and production control models, we need a formal function relationship between the failure rate and "maintenance effort" that shows how maintenance will affect the failure rate. Since that preventive maintenance can reduce machine breakdowns and therefore increase the mean machine up time (the reciprocal of the failure rate), such a function relationship must exist, this function relationship should exist even under the exponential up time assumption. Groenevelt, Pintelon and Seidmann (1992) assumed such a function by modeling maintenance effect by the maintenance budget level, but they did not indicate how the function can be established. Here, we suggest two possible ways to obtain the function. For both methods, we assume that the exponential up time assumption used in the queueing model only serves as an approximation for using the first moment information of the actual up time of the machine. In the first method, assume that the actual up time has a distribution function $F(t)$ and its failure rate function $a_0(t)$ ($= F'(t)/[1 - F(t)]$) is increasing in t. Following Barlow and Hunter (1960), we consider two maintenance policies;

Policy I: Perform preventive maintenance after t_0 time units of continuing operation without failure, and if the machine fails before t_0 units have elapsed, repair the machine as new and reschedule preventive maintenance;

Policy II: Perform preventive maintenance after the machine has been operating a total of t^* time units regardless of the number of intervening failures, and for each failure, only minimal repair is made (i.e. the machine failure rate is not disturbed after each repair).

Let $A = U/(U + D)$ where U is the total operating time per unit time and D is the total repair time per unit time. From Barlow and Hunter (1960), we have

$$A = \begin{cases} \dfrac{\int_0^{t_0} [1 - F(t)]dt}{\int_0^{t_0} [1 - F(t)]dt + E[R]F(t_0)}, & \text{for Policy I}, \\ \dfrac{t^*}{t^* + E[R] \int_0^{t^*} a_0(t)dt}, & \text{for Policy II}. \end{cases} \tag{23}$$

However, using (21), we have $A = E[S]/[E[S](1 + aE[R])] = 1/(1 + aE[R])$. Thus,

$$a = \begin{cases} \dfrac{F(t_0)}{\int_0^{t_0} [1 - F(t)]dt}, & \text{for Policy I}, \\ \dfrac{\int_0^{t^*} a_0(t)dt}{t^*}, & \text{for Policy II}. \end{cases} \tag{24}$$

That is, the failure rate a is a function of a given maintenance policy in which maintenance effort is measured by t_0 or t^*, the time interval between maintenance operations. This method for establishing a as a function of maintenance effort may also be used with other existing maintenance models.

The second method is based on Miller and Braff (1977). The following Markov chain model is used to describe the system behaviour. (a) The machine can be in one of the three states: *state* 1, operating, and there is no indication of a pending failure; *state* 2, operating, but there is an observable indication of a pending failure; *state* 3, failed. The transition rates are: from sates 1 to 2, a_1; from states 2 to 3, a_2; from states 3 to 1, $b = 1/E[R]$. The state transition from 1 to 3 or from 3 to 2 is impossible.

(b) When the machine is operating, preventive maintenance (PM) is performed every T time units, which is an exponential random variable with mean $E[T] = 1/m$. If the machine is in state 1, PM can do nothing; but if the machine is in state 2, PM will eliminate the pending failure and restore the machine in state 1.

Let P_i ($i = 1, 2, 3$) be the steady state probabilities tha the machine is in state i. We have the steady state equations of the Markov chain:

$$\begin{aligned} a_1P_1 &= mP_2 + bP_3, \\ (a_2 + m)P_2 &= a_1P_1, \\ bP_3 &= a_2P_2, \\ P_1 + P_2 + P_3 &= 1. \end{aligned}$$

Solving these equations, we obtain,

$$P_1 = \frac{1}{1 + \dfrac{a_1}{a_2 + m} + \dfrac{a_1a_2}{b(a_2 + m)}}$$

$$P_2 = \frac{\dfrac{a_1}{a_2 + m}}{1 + \dfrac{a_1}{a_2 + m} + \dfrac{a_1a_2}{b(a_2 + m)}}$$

$$P_3 = \frac{\dfrac{a_1a_2}{b(a_2 + m)}}{1 + \dfrac{a_1}{a_2 + m} + \dfrac{a_1a_2}{b(a_2 + m)}}.$$

Thus, the proportion of the time in which the machine is operating is

$$A = P_1 + P_2 = \frac{1}{1 + \dfrac{a_1a_2}{a_1 + a_2 + m}E[R]}. \tag{25}$$

Comparing this with $A = 1/(1 + aE[R])$ from (21), we see that

$$a = \frac{a_1a_2}{a_1 + a_2 + m}. \tag{26}$$

Thus, we obtain the failure rate a as a function of the frequency of preventive maintenance operations, m. Here a is a decreasing and convex function of m.

There are many other possible ways to establish the function relationship between the failure rate and maintenance effort. As suggested by Jardine and Hassounah (1990), in general, one can at least obtain such a function by using some statistical regression approaches. The failure rate/maintenance function is only one of the relationships that one may use for incorporating maintenance features into production control models. Other interesting function relationships that can also be put into our framework are the repair time training function, the service time/training function, the quality/inspection funcion, and etc. For a queuing model of this latter issue, see Hsu (1992).

An application of the $M/G/1$ vacation queue

Consider a single stage produce-to-order system where the machine is subject to breakdowns and repairs. Assume that customer orders (jobs) come to the system according to the Poisson process with rate λ, and the total time spent by a job in the machine is defined by S_A (19). Observe that if $\lambda E[S_A] < 1$, the machine will become idle (i.e., no job is waiting for processing) from time to time. Assume that whenever this happens, a preventive maintenance operation is performed on the machine. Further, if at the end of the maintenance operation, there is still no waiting job, another similar maintenance operation is performed on the machine. Such maintenance will continue until at the end of a maintenance operation, there is at least one job waiting for processing. Assume that each maintenance operation will take V time units to complete where V is an exponential random variable with mean v.

This system can be modeled as the $M/G/1$ queue with multiple vacations and exhaustive service (Doshi 1986). From Levy and Yechiali (1975), we have the mean job flow time of the system,

$$E[F] = \frac{\lambda E[S_A^2]}{2(1 - \lambda E[S_A])} + E[S_A] + v, \tag{27}$$

and the mean total maintenance time in each machine idle period,

$$\nu_{MV}(\nu) = \nu + \frac{1}{\lambda}. \tag{28}$$

Now, assume that the failure rate a and the mean repair time $r = E[R]$ can be affected by the maintenance operation. In particular, $a = a(\nu_{MV})$ and $r = r(\nu_{MV})$ are both decreasing and convex functions of ν_{MV}. We are interested in determining ν^* such that $E[F]$ is minimized. (The mean repair time can be reduced if the machine operator is responsible for repairing machine and is repeatedly training so that (s)he can do repairs faster). Since both a and r are assumed to be decreasing and convex in ν_{MV} and ν_{MV} is linear in ν (28), we have that both a and r are decreasing and convex in ν. From (27), we see that $E[F]$ is increasing and convex in $E[S_A]$ and $E[S_A^2]$, respectively. It is also easy to see from (21) and (22) that $E[S_A]$ and $E[S_A^2]$ are both increasing and convex in a and r, respectively (assume that $E[R^2]$ is increasing and convex in r). Combining these observations, we conclude that $E[F]$ is a convex function of v. Thus, $E[F]$ has a unique minimum.

The following set of data is used to test the behaviour of the model. Let S and R both be exponential random variables and $E[S] = 0.25$. Assume that

$$a(\nu) = \alpha a_0 + (1 - \alpha)a_0e^{-b\nu},$$

$$r(\nu) = \gamma r_0 + (1 - \gamma)r_0e^{-c\nu},$$

where $\alpha = 0.5$, $a_0 = 0.8$, and $b = 1$; $\gamma = 0.9$, $r_0 = 1$ and $c = 2$. As can be seen, these functions describe the diminishing effect of maintenance effort. Now, for the order arrival rate $\lambda = 1.8$, 2, and 2.2, we obtain the optimal $E[F^*]$ respectively as 2.265, 2.989, and 3.972, and the corresponding $\nu^* = 0.232$, 0.604, and 0.1045. It is interesting to compare these optimal mean flow times with the mean flow time $E[F_0]$ of the system without maintenance. For the corresponding λ, we have these $E[F_0]$ as 4.263, 8.5, and 89, respectively. With the optimal solution, the mean flow times are reduced by 47%, 65% and 96%, respectively. More importantly, as λ increases from 1.8 to 2.2, the mean flow time $E[F_0]$ of the system without maintenance has increased by 1988%, while the optimal mean flow time $E[F^*]$ has increased by only 75%. Thus maintenance is useful not only for reducing the mean flow time, but also for smoothing the production process.

Maintenance is useful not only for reducing the mean flow time, but also for smoothing the production process.

These results also show the importance of balancing maintenance with production. These fact that we have finite ν^* suggests that putting too much time on maintenance will worsen the system performance, this effect may not be obvious from traditional maintenance models where maintenance efforts is measured by cost. Although improper maintenance effort may indeed cost more, a general belief seems to be that maintenance always enhances system operating performance. But here we observe that this is only true if the proportion of time spent for maintenance is relatively small compared to that for processing jobs.

Conclusion

We have discussed the importance of viewing maintenance programs as part of the production process and showed how the joint production control and maintenance optimization model can be constructed. Clearly, there is much to do both for developing models and obtaining understanding of the joint problem and for applying the idea in real systems. As far as real applications are concerned, the analysis tool should certainly not be restricted only to the analytical model as we discussed. For example, simulation techniques may be more suitable for such purposes as pointed out by Banerjee and Burton (1990).

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References

Banerjee, A & Burton, J.S., "Equipment Utilization Based Maintenance Task Scheduling in a Job Shop", *European Journal of Operational Research* 45, 1990

Barlow, R & Hunter, L., "Optimum Preventive Maintenance Policies," *Operations Research* 8, 1960.

Buzacott, J.A. & Hanifin, L.E., "Models of Automatic Transfer Lines with Inventory Banks — A Review and Comparison," *AIIE Transactions* 10, 1978.

Buzacott, J.A. & Shanthikumar, J.C. "Stochastic Models for Manufacturing Systems," Prentice-Hall, Englewood Cliffs, NJ 1993.

Cho, D.I., & Parlar, M., "A Survey of Maintenance Models for Multi-unit Systems," *European Journal of Operational Research* 51, 1991.

Dallery, Y., & Gershwin, S.B., "Manufacturing Flow Line Systems: A Review of Models and Analytical Results," *Queueing Systems* 12, 1992

Dekker, R., "Applications of Maintenance Optimisation Models: A Review and Analysis," Technical Report, Erasmus University Rotterdam 1992.

Doshi, B.T, "Queueing Systems with Vacations — A Survey", *Queueing Systems* 1, 1986.

Groenevelt, H., Pintelon, & A. Seidmann, A., "Production Batching with Machine Breakdowns and Safety Stocks," *Operations Research* 40, 1992.

Hsu, L.-F., "Optimal Preventive Maintenance Policies in an M/G/l Queue-Like Production Systems," *European Journal of Operational Research* 58, 1992.

Jardine, A.K.S., "Maintenance, Replacement and Reliability," Pitman Publishing, UK 1973. (Reprints available from University of Toronto Bookstores)

Jardine, A.K.S. & Hassounah, M.I., "An Optimal Vehicle-Fleet Inspection Schedule," *J. Opl. Res. Soc.*41, 1990.

Koenigsberg, E., "Production Lines and Internal Storage — A Review," *Management Science* 5, 1959.

Lee, H.L., & Rosenblatt, M.J., "A Production and Maintenance Planning Model with Restoration Cost Dependent on Detection Delay," *IIE Transactions* 21, 1989.

Levy, Y., & Yechiali, U., "Utilization of Idle Time in an M/G/l Queueing System," *Management Science* 22, 1975.

Miller, G.H., & Braff, R., "Impact of the Frequency of Technician Visits on Facility Failure Rate," *IEEE Trans. on Reliability R*-26, 1977.

Pintelon, L.M., & Gelders, L.G., "Maintenance Management Decision Making," *European Journal of Operational Research* 58, 1992.

Posner, M.J.M., & Berg, M., "Analysis of a Production-Inventory System with Unreliable Production Facility," *Operations Research Letters*, 8, 1989.

Ross, S.M., "Stochastic Processes," John Wiley, New York, 1983

Silver, E.A., Peterson, R., "Decision Systems of Inventory Management and Production Planning," John Wiley, New York 1985.

Srinivasan, M.M., & Lee, H-S, "Random Review Production/Inventory Systems with Compound Poisson Demands and Arbitrary Processing Times," *Management Science* 37, 1991.

Valdez-Flores, C., & Feldman, R.M., "A Survey of Preventive Maintenance Models for Stochastically Deteriorating Single-unit Systems," *Naval Research Logistics Quarterly* 36, 1989. □

> If language be not in accordance with the truth of things, affairs cannot be carried on success.
>
> – Confucius

Manufacturing Management Principles in Hong Kong

Hing Yau Victor Lo

Hong Kong is facing a revolutionary period in manufacturing management. Traditional management focuses have gradually changed from quantity to quality. The author describes the situation in Hong Kong manufacturing industries, and analyzes the changes in manufacturing management practices. He has also carried out a survey to verify such changes and concludes that Hong Kong manufacturing industry is moving on to a quality conscious era, with Total Quality Management (TQM) and Quality Assurance Management System, mainly the ISO 9000 as the keys.

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To improve Hong Kong's economic performance and wealth, its many hundreds of companies, large and small, need to improve their competitiveness. The Australian Manufacturing Council (1990) has expressed it as businesses, not countries, that are the primary vehicles for industrial competitiveness. Boeing, not the USA, leads the world in commercial aircraft and IBM in computers; and it is BHP, and not Australia that has a strong position in exporting coated steel. One of the important methods to improve performance is to upgrade the manufacturing management practices of the local companies. Due to the change in customer consciousness towards better quality, local industrialists have to understand the link between quality and the management philosophy. Since Hong Kong is likely to be returned to China in 1997, a strong economy is the best safeguard for the political changes in the offing. The only viable strategy for the 90s is to add value to the manufacturing industries and improve the quality of output. The importance of the manufacturing sector and difficulties it faces were outlined in the Governor's annual address to the Legislative Council. He said that the success of the economy depends heavily on the ability of private employers to maximize productivity. This implies the necessity of better manufacturing management among the manufacturing industries.

The only viable strategy for the 90s is to add value to the manufacturing industries and improve the quality of output.

Manufacturing in Hong Kong

The three major manufacturing industries in Hong Kong are:

- Electronics and Electrical Products
- Textiles and Garments
- Plastics and Toys

Electronics *and Electrical Products*: In this sector the finished products are mostly consumer electronics for home and personal use. Major categories include electronic watches and clocks, computers and peripherals, corded and cordless telephones, radios, cassette recorders, television sets, electronic games, calculators, blank video and audio tapes. Some of the newer products include photocopiers, electronic typewriters, video telephones, cellular telephones facsimile machines, electronic cash registers, compact disc players, LCD projection panels and programmable controllers. Though still competitive, Hong Kong's electronics industry is in risk of falling far behind regional competitors. Therefore, the maintenance of quality is very critical for the industry to retain its market.

Textiles and Apparels: The textiles and the apparel industry has been a major factor of significance in the development of Hong Kong economy over the past 25 years (currently over 10000 factories). The industry employs more than 40 per cent of the direct work force employed in Hong Kong factories and directly and indirectly supports approximatly 40 per cent (more than 300000 workers) of all employment in Hong Kong.

Plastics and Toys: Hong Kong is famous for plastic toys, including dolls, doll houses and other accessories, toy figures, educational building blocks, miniature household utility sets and gimmicks such as beauty kits, doctor's kits, etc. The industry has been one of Hong Kong's major export earner, accounting for 3 per cent of the territory's total exports. Hong Kong had been the world's leading toy exporter for years. It ranked second after Taiwan in 1988, mainly due to production shift to China. Hong Kong's domestic exports and re-exports of Chinese toys combined still exceeded Taiwan's exports.

Manufacturing Management in Hong Kong

Hong Kong's economy depends on the export of goods to a great extent. Earlier, mass production and high efficiency were the predominant factors in the success of these industries, while quality was a second concern. Blessed with abundant supplies of cheap labour, Hong Kong was well known for its low prices and speed in production. However, the scenario has changed drastically today, competitors have surpassed Hong Kong and deprived it of supremacy in trading position, necessitating the old way of manufacturing management to be thoroughly overhauled to suit the present global markets.

In the past, local manufacturing companies displayed indifference to upgrading the quality. In an organization, the workers had a limited role. Senior managers were responsible for major business decisions, middle managers set productivity standards and workers merely did the job. All of them paid very little or no attention to quality.

Twenty to thirty years ago, the manufactures' emphasis was on quantity rather than quality. A major movement towards quality could be dated back to the early 80s when there began a global demand for quality. In response, in 1981, the Hong Kong Productivity Council organized and sent a study mission to Japan to study QCC, which participated in several seminars. QC circle concepts and techniques were disseminated very rapidly in Hong Kong through both public and in-company seminars, training courses. This marked the start of the quality movement and awareness in Hong Kong industries. However, quality still remained at a relatively low level in the hierarchy.

During the mid 80s, Hong Kong's products still maintained a stable share in the markets. There was no significant government support or incentive to upgrade quality and only a few of the manufacturing companies had 'quality' as the focus of their manufacturing management. However, following the introduction of the ISO 9000 in 1987, Hong Kong manufacturers and government became aware of the importance of quality for the continual survival and success of their industry. The government became increasingly involved in promoting effective quality management systems in manufacturing. The Industry Department maintains measurement and documented standards as authoritative reference points for industry. It also provides calibration services and operates a laboratory accreditation scheme. The Hong Kong Quality Assurance Agency (HKQAA) was formed in September 1989 as a limited company for quality certification on Quality Assurance Management System – the ISO 9000 series.

The Governor's Award for Industry was also established in 1989 to recognize and encourage excellence in different aspects of industrial performance. One of the trophies is for quality and is awarded to manufacturers who have over the past year provided effective quality management systems and manufactured products adhering to a high standard of quality.

The strategic importance of quality was also reflected by the fact that in March 1990, the Governor personally launched a long-term Quality Awareness Campaign for the Hong Kong Industry Department. This campaign carries an initial budget of HK$9 million (approx, US$ 1.15 million) for a period of three years. The underlying philosophy of the campaign is a 'top-down' approach that targets high-level executives to secure the commitment and active involvement of companies in implementing quality and to develop a long-term strategic vision in quality. The aim of the campaign is to increase the quality awareness of local manufacturers and bring the concept to them that sound quality management will lead to improved productivity, profitability, and competitiveness. The campaign's emphasis is first on top management, and then on line managers and finally on the front line workers. The principal message conveyed to the chief executives is that the introduction of a well-structured quality management system as an integral part of the company's business plan would help reduce cost, improve output and secure markets.

Sound quality management will lead to improved productivity, profitability, and competitiveness.

Survey on Manufacturing Management

To understand more about the current situation an in-depth personal interview survey was carried out with the following objectives:

- To find out the vision of local manufacturers with regard to their businesses and quality;
- To share successful local manufacturing management.
- Analyze the prevalent trends in the current scenario of the manufacturing management.

The sample was from managers or professionals; either male or female; who are familiar with the local manufacturing industries and quality. A total of 67 companies were approached, the response rate being around 58 per cent. In the case of those companies which responded to the questionnaire and where the name of the respondent was referenced in the questionnaire, a further telephone follow-up was carried out to discuss the matter more elaborately.

The findings of the survey can be summarized as follows: The common trend is that organizations are implementing quality improvement movements. In the late 80's, they developed a new TQM approach to suit local needs. Bodies such as the Hong Kong Quality Management Association etc. provide quality training courses tailored for local industries. For instance the University of Hong Kong and the Hong Kong Q-Mark council regularly provide 'Company wide training and consultancy programme on ISO 9000 certification' at a relatively low cost. All these activities contribute a lot to the quality improvement of the local manufacturing sector.

There are several changes in the manufacturing management in the last few years. First, top executives and managers have become involved in the quality improvement programme. The quality control department is playing a coordinating function, while major quality related decisions are made in the board room. ISO 9000 implementation seems to be an obvious leading cause for such changes. Second, due to keen competition and slack market share growth, 'Every thing is fine and there are no problems at all' concept has gone. People realize that the competitors have implemented quality improvement programmes, and the most popular topics in modern manufacturing management in Hong Kong are TQM and ISO 9000. Third, as a result of quality promotion programmes by various institutions and Government, people have become more aware and receptive to lessons from other successful companies.

Due to keen competition and slack market share growth, 'Every thing is fine and there are no problems at all' concept has gone.

Conclusion

It is becoming increasingly clear that 'Quality' is one of the determining factors to success in world trade. The enormous intensification of the world competition during the last five years have made Hong Kong manufacturing industries change their traditional ways and adopt a new concept of management with 'Total Quality and ISO 9000' as the emphasis. The model of manufacturing management using TQM and ISO 9000 indeed is the feasible solution to improve the competitiveness of Hong Kong industries. □

Feature

Optimum Inventory Policy for Duopolistic Situation

R.G. Bhatt & B.B. Jani

In this paper an attempt is made to determine the optimum inventory level for two brands of the given product with a view to maximize the profit contribution of a brand under consideration. The inventory conditions under which the model gives equilibrium solution is derived. The equilibrium solution has been found by simultaneously maximizing the profit function of both the competitor brands. The sensitivity of the small deviations from their equilibrium values in the decision variables is also tested. With the help of numerical problem, it is shown that if both the brands compete at the stated inventory level then they can maximize their profit.

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In a duopolistic situation, the inventory level of the product holds the key to maximisation of profit. The inventory condition under which the model gives equilibrium solution is to be derived for determining the optimum inventory policy.

The following assumptions are made for determining the optimum inventory level.

- Only two brands of a product are competing in the market.
- The total anticipated sales volume (V) of the product is fixed.
- Let demand of the ith brand (D_i) be unknown and it is assumed that it depends on the competitor brand's strategy.
- Let total number of runs (n_i) of quantity produced be known for i^{th} brand, $i = 1,2$ and Q_i denote the lot size in each production run of i^{th} brand.
- The setup cost for i^{th} brand is C_{si} per production run, $i = 1,2$, holding cost is C_{1i} per unit in inventory for a unit time for $i = 1,2$, and logistic margin (h_i) of the i^{th} brand is defined as the difference between unit price (P_i) and unit variable cost (C_i) for $i = 1,2$.
- It is further assumed that as soon as the inventory level reaches zero, replenishment is made. Thus shortages are not allowed to occur.
- Production of the commodity is uniform.
- Lead time is zero.
- Each competitor brand not only knows his number of production runs, inventory holding cost and logistic margin but also the same for the opponent brand and tries to maximize his profit.
- The competitor brand's share of market depends on his relative demand in the market.

Problem Formulation

For ith brand it is assumed that after each time t_i, the quantity Q_i is produced or supplied throughout the entire period (say one year). Now if n_i denotes the total number of runs of quantity produced during the year, we have

$$n_i t_i = 1,\ D_i = n_i Q_i,\ i = 1,2\ . \tag{1}$$

Also for the basic EOQ model [1] of i^{th} brand, we have,

$$\text{Total annual cost} = \left[\text{Annual inventory holding cost}\right] + \left[\text{Annual costs associated with runs of size } Q_i \text{ for ith brand}\right]$$

i.e., $$\text{Total Cost } C_{Ai} = \frac{1}{2} Q_i C_{1i} + n_i C_{si},\ i = 1,2 \tag{2}$$

Here we have considered a fixed market in which only two brands are competing and total market potential represents the total anticipated sales of both the competitors under a given set of strategies.

The contribution of demand to the market share of ith brand is proportional to

$$\frac{D_i}{D_1 + D_2} \text{ for } i = 1, 2 \text{ respectively*}$$

Then the anticipated profit function for i^{th} brand is given by

Profit = (Total anticipated sales volume) (Margin of profit) – (Inventory expenditure) – (Fixed expenditure)

i.e. $$P_i = V\left[\frac{n_i Q_i}{n_1 Q_1 + n_2 Q_2}\right] h_i - C_{Ai} - F_i,\ i = 1,2. \tag{3}$$

where for i^{th} brand,

P_i = Profit
V = Fixed anticipated unit sales volume
C_i = Unit variable cost
h_i = Logistic margin and
F_i = Fixed cost.

The problem here is to find equilibrium points for both the competitor brands in the sense that if any brand deviates from the equilibrium values, its anticipated payoff goes down.

Necessary and Sufficient Conditions

Since both Q_1 and Q_2 are positive, the necessary and sufficient conditions for the maximum profit of ith competitor (i = 1,2) are given by

$$\frac{\delta P_i}{\delta Q_i} = 0$$

$$\frac{\delta^2 P_i}{\delta Q_i^2} < 0$$

From (3), it can be shown that for i = 1,

$$\frac{\delta P_1}{\delta Q_1} = \frac{V(n_1 n_2 Q_2) h_1}{(n_1 Q_1 + n_2 Q_2)^2} - \frac{1}{2} C_{11} \tag{4}$$

$$\frac{\delta^2 P_1}{\delta Q_1^2} = -\frac{2V(n_1^2 n_2 Q_2) h_1}{(n_1 Q_1 + n_2 Q_2)^3} \tag{5}$$

Similarly for i = 2

$$\frac{\delta P_2}{\delta Q_2} = \frac{V(n_1 n_2 Q_1) h_2}{(n_1 Q_1 + n_2 Q_2)^2} - \frac{1}{2} C_{12} \tag{6}$$

$$\frac{\delta^2 P_2}{\delta Q_i^2} = 2 - \frac{2V(n_1 n_2^2 Q_1) h_2}{(n_1 Q_1 + n_2 Q_2)^3} \tag{7}$$

From (5) and (7), it can be observed that the sufficient condition $\frac{\delta^2 P_i}{\delta Q_i^2} < 0$, i = 1,2 is satisfied for achieving maximum profit.

Using necessary condition $\frac{\delta P_i}{\delta Q_i} = 0$, i = 1, 2 results (4) and (6) can be rewritten as :

$$\frac{V(n_1 n_2 Q_2) h_1}{(n_1 Q_1 + n_2 Q_2)^2} = \frac{1}{2} C_{11} \tag{8}$$

$$\frac{V(n_1 n_2 Q_1) h_2}{(n_1 Q_1 + n_2 Q_2)^2} = \frac{1}{2} C_{12} \tag{9}$$

Simultaneous Optimization Conditions

From Eqs. (8) and (9)

$$\frac{V(n_1 n_2 Q_2) h_1}{\frac{1}{2} C_{11}} = (n_1 Q_1 + n_2 Q_2)^2 \tag{10}$$

$$\frac{V(n_1 n_2 Q_1) h_2}{\frac{1}{2} C_{12}} = (n_1 Q_1 + n_2 Q_2)^2 \tag{11}$$

Equating results (10) and (11) and dividing both the sides of the equation by $Vn_1 n_2$, we obtain the equilibrium condition as:

$$\frac{Q_1}{Q_2} = \frac{h_1}{h_2}\left(\frac{C_{12}}{C_{11}}\right) \tag{12}$$

* The demand term is similar to the form indicated by Ackoff et al (1984).

Determination of Optimum Inventory Level

From (12), we have

$$Q_2 = \frac{h_2}{h_1}\left(\frac{C_{11}}{C_{12}}\right) Q_1 \qquad (13)$$

Using the result (13) in (9) and simplifying we get

$$Q_1 = \frac{(1/2\,C_{12})\,(n_1 Q_1 + n_2 (h_2/h_1)(C_{11}/C_{12}) Q_1)^2}{V (n_1 n_2) h_2}$$

and on further simplification we obtain

$$Q^{\circ}_1 = h_1 C_{12} H \qquad (14)$$

where

$$H = \frac{2V n_1 n_2 h_1 h_2}{[n_1 h_1 C_{12} + n_2 h_2 C_{11}]^2}$$

Similarly optimum inventory level for brand 2 can be obtained as :

$$Q^{\circ}_2 = h_2 C_{11} H \qquad (15)$$

Sensitivity Analysis

Let Brand 1 be the brand under consideration and Brand 2 the opponent brand. We measure the sensitivity of net profit contribution for Brand 1 with respect to its inventory quantity as well as that of its opponent.

Change in the inventory level of brand under consideration

Let us assume that new inventory level of the given brand is

$$Q'_1 = Q_1 + \delta$$

where δ is a small nonzero constant

Hence from Eq. (3), new profit contribution function is given by

$$P'_1 + F_1 = Vh_1\left[\frac{n_1Q_1 + n_1\delta}{n_1Q_1 + n_1\delta + n_2Q_2}\right] - \left(\frac{1}{2}(Q_1+\delta)C_{11} + n_1 C_{S1}\right)$$

Considering $D = n_1 Q_1 + n_2 Q_2$, we have

$$P'_1 + F_1 = Vh_1\left[\frac{n_1Q_1 + n_1\delta}{D}\left(1 + \frac{n_1\delta}{D}\right)^{-1}\right] - \frac{1}{2}\delta C_{11} - \left[\frac{1}{2}Q_1 C_{11} + n_1 C_{S1}\right]$$

$$= Vh_1\left[\frac{n_1Q_1 + n_1\delta}{D}\left(1 - \frac{n_1\delta}{D} + \left(\frac{n_1\delta}{D}\right)^2\right)\right] - \frac{1}{2}\delta C_{11} - C_{A1} \text{ (Ignoring the higher powers of } \delta$$

i.e. $$P'_1 + F_1 = (P_1 + F_1) + Vh_1\left[\frac{n_1\delta}{D} + \frac{n_1 Q_1 + n_1 \delta 6}{D}\left(-\frac{n_1\delta}{D} + \left(\frac{n_1\delta}{D}\right)^2\right)\right] - \frac{1}{2}\delta C_{11}$$

$$= (P_1 + F_1) + \frac{Vh_1n_1\delta}{D}\left[1 + \frac{n_1 Q_1 + n_1\delta}{D}\left(-1 + \left(\frac{n_1\delta}{D}\right)\right)\right] - \frac{1}{2}\delta C_{11}$$

Since from (10) under optimization condition we have,

$$\frac{V(n_1 n_2 Q_2) h_1}{D^2\left(\frac{1}{2}C_{11}\right)} = 1,$$

the above expression can be rewritten as

$$P'_1 + F_1 = (P_1 + F_1) + \frac{Vh_1n_1\delta}{D}\left[1 + \frac{n_1 Q_1 + n_1\delta}{D}\left(-1 + \left(\frac{n_1\delta}{D}\right)\right)\right] - \frac{1}{2}\delta C_{11}\left[\frac{Vh_1n_1n_2Q_2}{D^2 (C_{11}/2)}\right]$$

$$= (P_1 + F_1) + \frac{Vh_1n_1\delta}{D^3}\left[1 + \frac{n_1 Q_1 + n_1\delta}{D}\left(-1 + \left(\frac{n_1\delta}{D}\right)\right) - \frac{n_2 Q_2}{D}\right]$$

$$= (P_1 + F_1) + \frac{Vh_1n_1\delta}{D}\left[-\frac{n_1\delta}{D} + \frac{(n_1Q_1 + n_1\delta)(n_1\delta)}{D^2}\right]$$

which means that

$$(P'_1 + F_1) - (P_1 + F_1) = -\frac{Vh_1 (n_1\delta)^2}{D^3}[n_2Q_2 - n_1\delta] \qquad (16)$$

The above quantity is negative only if $n_2Q_2 > n_1\delta$. This suggests that under given condition if Brand 1 deviates from its optimal policy, its profit goes down.

Change in the competitor's inventory level

If the new inventory level of opponent brand is $Q'_2 = Q_2 + \delta$, we have

$$P'_1 + F_1 = Vh_1 \left[\frac{n_1 Q_1}{n_1Q_1 + n_2Q_2 + n_2\delta}\right] - C_{A1}$$

$$= Vh_1 \left[\frac{n_1Q_1}{D}\left(1 + \frac{n_2\delta}{D}\right)^{-1}\right] - C_{A1}$$

(where $D = n_1 Q_1 + n_2 Q_2$)

$$= Vh_1 \left[\frac{n_1Q_1}{D}\left(1 - \frac{n_2\delta}{D} + \left(\frac{n_2\delta}{D}\right)^2\right)\right] - C_{A1}$$

(Ignoring higher powers of δ)

That is

$$P'_1 + F_1 = (P_1 + F_1) + Vh_1 \left[-\frac{n_1Q_1}{D}\left(\frac{n_2\delta}{D} + \left(\frac{n_2\delta}{D}\right)^2\right)\right]$$

and hence

$$P'_1 + F_1 - (P_1 + F_1) = Vh_1 \left(\frac{n_1Q_1}{D}\right)\left(\frac{n_2\delta}{D}\right) + \left(-1 + \frac{n_2\delta}{D}\right)$$

$$= -Vh_1 \frac{(n_1Q_1)(n_2\delta)}{D^3} (n_1 Q_1 + n_2 (Q_2 - \delta)) \quad (19)$$

Here the difference only depends on the value of δ since $V Q_1$, Q_2, n_1 and n_2 are all positive and $Q_2 > \delta$. This means that if competitor is increasing his inventory level (i.e. $\delta > 0$), the profit of brand under consideration will go down and if he is decreasing his level (i.e. $\delta < 0$) the profit of brand under consideration will increase.

Application of the Model

Let us suppose that only two brands, called X_1 and X_2 are competing in a market in which total anticipated sales of product is fixed as 10,000 units.

We are given the following information:

Table 1: Production Conditions of both brands of Products

Brand (X_1)	Logistic margin (h_1) (in Rs.)	Inventory holding cost per unit (C_{11}) (in Rs.)	Total no. of production runs (n_1) per year	Setup cost (C_S) per production run (in Rs.)
X_1	4.00	0.60	5	18
X_2	2.75	0.40	6	16

Using the above information the optimum inventory level and profit contribution for both the brands can be obtained as:

Table 2: Optimum Inventory level

Brand (X_1)	Optimum inventory level (Q°_i) (in Rs.)	Optimum profit contribution ($P^\circ_i + F_i$) (in Rs.)
X_1	719.08	14,964.15
X_2	741.55	17,574.28

Here it can be verified that

$$\frac{Q^\circ_1}{Q^\circ_2} = \frac{h_1}{h_2}\left(\frac{C_{12}}{C_{11}}\right) = 0.9697$$

According to the above, if Brand X_2 deviates from its optimal strategy and if its new inventory level ($Q'_2{}^\circ$) is Rs. 800 then Brand X_1 also has to change its strategy to maintain equilibrium and now its optimal inventory level will be

$$Q'_1{}^\circ = \frac{h_1}{h_2}\left(\frac{C_{12}}{C_{11}}\right) Q'_2{}^\circ$$

$$= 775.76 \text{ Rs.}$$

Concluding Remarks

Interesting and suggestive results are obtained for optimal inventory level determination from this case when the optimum outlay and profit equations are examined closely. This reveals that:

- The ratio of the optimal inventory of the two brands is equally proportionate to their logistic margins and inversely proportionate to the ratio of their inventory holding costs.
- The determination of the inventory level of the brand under consideration depends on the product's total anticipated sales volume, the number of production runs, logistic margin, and inventory, holding cost for both the brands.
- A relatively small change in the brand's inventory level can cause large changes in the brand's profit by adopting an appropriate inventory strategy.
- Whenever a brand keeps less inventory level than its equilibrium amount while its competitor keeps equilibrium inventory level, it diminishes its own profits but greatly improves those of its competitor. But whenever a brand has more inventory level than its equilibrium amount and its competitor maintains the equilibrium level, it again impairs its own profits but infiicts far greater injury on its competitor. Thus the competitor's profits are more sensitive to a change in the level of inventory as compared to the profits of the brand making the change.

Reference

Ackoff, R.L. & Sasieni, M.W., "Fundamentals of Operations Research", New York : Wiley International Edition, John Wiley and sons, Inc., (1984). □

steel plant to study its performance in the areas of concern of different interest groups for a ten-year period (from 1979-80 to 1988-89) with reference to a chosen base period (1978-79). To reflect the extent of impact on the different areas of concern for the various interest groups in the specific case under study, suitable measures (surrogates wherever necessary) have been formulated (as presented in table 1).

The extent of contribution made by the organization to the different areas relevant to the different interest groups has been assessed during the ten-year period relative to the base period. With equal priority to the different interest groups and the different areas of concern within each interest group, the sum total of relative contribution to the consumers, the national economy and the society has been judged in relation to the corresponding

Table 1. Assessment of contribution to the different areas

Interest group	Area of concern	Assessment
Share holders	Profitability	Performance measure Return on investment (i.e. Profit after tax/average networth)
Consumers	(i) Volume of Outputs (i.e. activity level)	Sales value for different product groups at constant average base prices.
	(ii) Quality of outputs (i.e. Quality level)	Extra realization on top of best steel prices (as fixed by the government from time to time) for quality and section extras.
	(iii) Cost of outputs (i.e. Cost effectiveness level)	Cost effectiveness measured by sales value in relation to inflation adjusted corresponding revenue expenses.
National economy	(i) Facilitation of indigenous technology development	Considered to be a function of (a) proportion of R & D expenditure in total expenditure for gross value addition. (b) Imported material cost proportion in total expenditure for gross value addition. (c) Proportion of imported plant and equipment in the gross block (inflation adjusted) for the plant facilities.
	(ii) Conservation of non-renewable natural resources	Factor productivity levels of the relevant resources used i.e. iron ore and coal.
	(iii) Conservation of scarce national resources	Factor productivity levels of scarce resources used i.e., productivity of purchased electrical power consumed and working capital turnover ratio (for working capital).
	(iv) Foreign exchange earning	
	(v) Facilitation of industrial growth	Export sales proportion in total sales considered to be a function of (a) Inflation adjusted purchase for raw materials, semi-finished and finished goods (b) Conversion charges (inflation adjusted) payable to the re-rollers (c) Investments (inflation adjusted) in subsidiary and ancillary units.
Society	(i) Generation of employment opportunities - direct	Average no. of employees
	(ii) Generation of employment opportunities - indirect	Considered to be the function of (a) Level of direct employment (b) Purchasing power of the employees (real salary level) (c) Levies and taxes (real) paid to the govt.
	(iii) Facilitation of community development and social disparity removal	Considered to be function of (a) Inflation adjusted expenditure on community development and social welfare projects (b) Proportion of handicapped employees and those belonging to socially backward classes.
	(iv) Protection of the environment	Inflation adjusted expenditure related to environment protection.

Table 2: Contribution to different interest groups in their ares of concern

	1978-79 (base year)	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	Average for the ten year period
A. Shareholders as the interest group												
Profitability performance index (i.e. returns on average networth index)	1.00	0.87	1.32	2.05	1.63	0.68	2.53	2.39	1.55	1.34	1.74	1.61
B. Consumers as the interest group												
Activity level index	1.00	0.95	0.97	1.06	1.14	1.15	1.26	1.31	1.44	1.48	1.51	1.23
Quality level index	1.00	1.05	1.01	1.19	1.11	1.15	1.25	1.16	1.15	1.21	1.24	1.15
Cost effectiveness index	1.00	0.98	1.01	1.11	1.01	1.01	1.11	1.11	1.08	1.12	1.13	1.07
Group contribution index	1.00	0.99	1.00	1.12	1.09	1.10	1.21	1.19	1.22	1.27	1.29	1.15
C. National economy as the interest group												
Facilitation of indigenous technology development index	1.00	.124	1.22	1.12	0.96	0.88	0.89	0.52	0.66	0.61	0.60	0.87
Conservation of natural resources index	1.00	0.97	0.96	0.94	0.93	0.97	1.02	1.09	1.11	1.04	1.08	1.01
Conservation of scarce resources index	1.00	1.28	1.61	1.28	1.08	1.12	1.21	1.28	1.22	1.16	1.20	1.24
Foreign exchange earning index	1.00	0.22	0.61	0.22	0.33	0.06	0.39	0.53	0.11	0.61	1.50	0.46
Facilitation of industrial growth index	1.00	0.97	1.02	1.15	1.47	1.44	2.54	2.89	2.92	2.83	2.95	2.02
Group contribution index	1.00	0.94	1.08	0.94	0.95	0.89	1.21	1.26	1.20	1.25	1.47	1.12
D. Society as the interest group												
Direct employment generation index	1.00	1.03	1.05	1.10	1.08	1.07	1.05	1.15	1.15	1.15	1.15	1.10
Indirect employment generation index	1.00	1.12	1.07	1.27	1.02	0.95	0.97	1.06	1.07	1.08	1.10	1.07
Facilitation of community development and social disparity removal index	1.00	1.03	1.06	1.07	1.11	1.12	1.18	1.20	1.23	1.24	1.26	1.15
Environment protection index	1.00	1.04	1.06	1.11	1.17	1.25	1.33	1.38	1.44	1.62	1.70	1.31
Group contribution index	1.00	1.06	1.06	1.14	1.10	1.10	1.13	1.20	1.22	1.27	1.30	1.16
Total contribution (excluding profit) index	1.00	1.00	1.05	1.07	1.05	1.03	1.18	1.22	1.21	1.26	1.35	1.14
Performance (other than profitability) index [i.e. total contribution (excluding profit) index related to average networth index]	1.00	0.95	0.92	0.80	0.67	0.61	0.62	0.47	0.38	0.32	0.27	0.60
F. Total performance index (i.e. towards profitability and other than profitability)	1.00	0.91	1.12	1.43	1.15	0.65	1.58	1.43	0.97	0.83	1.01	1.10

relative arearage networth deployed as "other than profitability performance" of the organization. The 'profitability performance' and 'other than profitability performance' together represent the total performance of the organization as presented in table 2.

The total performance of an organization is reflected not by the returns alone but also by its impact on the consumers, the national economy and the society at large in relation to its investment base.

Share holders as the interest group

The profitability performance of the organization has been significantly above the base level during the period under study (except the year 1979-80 and 1983-84) with an average for the ten-year period being 6 per cent above the base level (as shown in figure 1). Such a variation is mainly due to the following reasons.

With an increased activity level (except during the first two years) and quality improvement in general, together with steel price rise as revised by the government from time to time, the turnover of the organization has increased by 28 per cent per annum on an average during the period under study. With such an increased level of turnover, the amount of profit (before depreciation and taxes) earned on turnover has been varying between a minimum of 7.10 per cent during 1983-84 to a maximum of 16.10 per cent during the year 1985-86 with an average for the period being 12.50 per cent against the base year figure of 11.82 per cent. Such a variation in the percentage of profits on turnover has been mainly due to the impact of the factors like

- the extent of availability of sanctioned power from the external sources with consequent variation in the proportion of semi-finished steel production and the conversion charges payable to the re-rollers to improve the proportion of finished steel in saleable steel despatches;
- variation in the payment of interest charges pertaining to term loan to support the capital expenditure programme of the organization;
- variation in the amount of purchased fuel.

With variation in profitability (before depreciation and taxes) as above together with the variation in the amount of depreciation charged over the years depending on the completion of different phases of capital expenditure programme and the amount of taxes payable, the amount of profit after tax earned has been improved significantly over the years to the tune of 28 per cent per annum on an average during the period under study.

With an ever increasing level of profits earned and a nominal growth in dividend payment (by way of cash and bonus shares), the average networth deployed by the organization has been on the increasing track, increased to the tune of 13 per cent per annum on an average during the ten-year period.

Consumers as the interest group

The activity level has been below the base year mark during the first two years, thereafter improved consistently over the years (as shown in table 2) mainly due to the following reasons.

- Production has been constrained during the first two years due to non-availability of coking coal and sanctioned power from the external sources.
- With increase in the capacity of captive collieries and washeries, coal production, so also the proportion of washed coal, have improved over the years.
- With increased proportion of washed coal and higher proportion of sinter in the burden used, (along with super-fluxed sinter), in the blast furnaces, the coke consumption rate per tonne of hot metal production has decreased significantly with subsequent increase in the level of hot metal and consequent saleable steel production.
- With the introduction of further processing of by-products and acquisition of two other allied manufacturing units, activity level has gone up significantly during the last five years.

The quality of saleable steel outputs, though varying over the years, has improved in general primarily due to the introduction of more modern process control instruments at different stages of iron and steel making.

The cost effectiveness index has been marginally improved with the average for the ten-year period during 7 per cent above the base level mainly due to the following reasons:

- Higher proportion of iron ore fines utilized through increased proportion of sinter produced and charged in the blast furnaces.
- Better scrap recovery and utilization.

- Increased level of energy productivity achieved over the years due to the use of higher proportion of washed coal as well as imported coal having lower ash content, and also due to installation of more process control instruments.
- The saving in cost, however, has been offset to some extent by the increase in man-related cost and conversion charges paid to the re-rollers.

As a result, the group contribution index for the consumers has though varying, improved over the years from 1981-82 onwards (as shown in figure 2).

National economy as the interest group

The efforts of the organization towards adoption and development of indigenous technology has been insignificant, only a nominal amount has been spent on research and development activity. In fact, the use of imported coking coal and capital equipments have made the indigenous technology development index decline more and more over the years as reflected in table 2.

The marginal improvement in conservation of natural resources, particularly during the last five years (as in table 2) has been mainly due to better utilization of iron ore fines and scrap and lower coke consumption rate over the years. However, the consumption of steam coal has gone up in the mean time to generate more captive power particularly to meet the shortfall in power supply from the external sources.

Out of the two main scarce resources used, the consumption of power from the external source has been less due to shortfall in the sanctioned supply itself against which the organization has augmented its captive power generation. Working capital, the other scarce resource, has been used more effectively by the organization over the years. As a result, the conservation of scarce resources index has improved quite significantly (as shown in table 2).

The company has been able to improve the quality of its outputs and marginally reduce the cost; however, it is yet to reach international standards, with occasional exports as reflected by the relevant index in table 2.

The extent of facilitation of industrial growth has significantly improved over the years mainly due to –

- Higher level of investments made particularly during the last five years to support the different client organizations;
- Increased level of dependence on the re-rollers for converting the semi-finished steel.

Based in the above, the contribution index, relevant to the national economy as the interest group, reflects a varying trend (11 per cent below to 47 per cent above) with the ten year average being 12 per cent above the base year mark as shown in figure 2.

Society as the interest group

The total average number of employees of the organization (as reflected in the relevant index in table 2) has increased during the first three years due to recruitment of additional manpower required for modernization. Thereafter, it has decreased during the next three years with the adoption of 'no new recruit' policy by the organization and normal retirement. However, during the year 1985, it has increased suddenly due to acquisition of two allied manufacturing units.

Indirect employment generation has been marginally above the base year figure (except in two years) due to variation in the level of direct employment generation as mentioned, gradual increase in the rate of remuneration (real) to the extent of 45 per cent by the year 1988-89 and

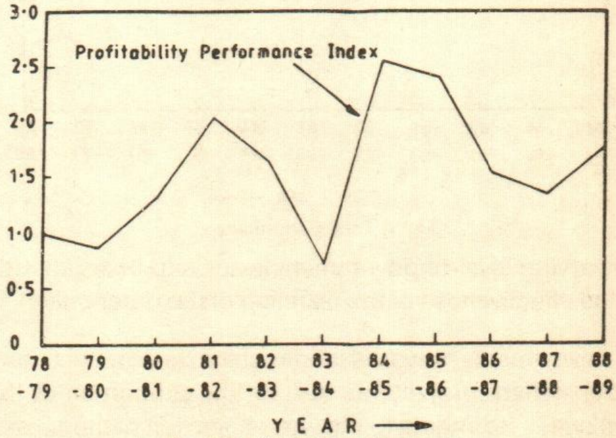

Fig. 1 Profitability performance.

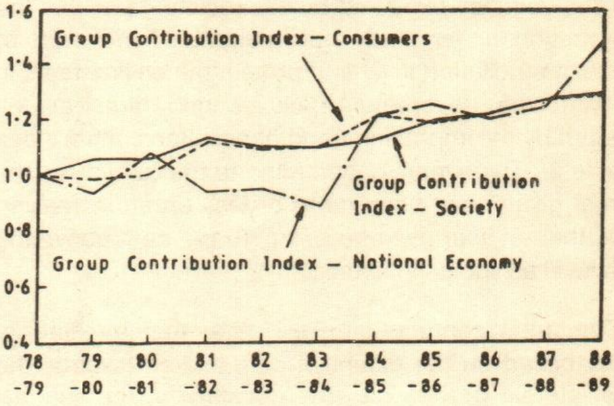

Fig. 2 Contribution to different interest groups. (other than shareholders)

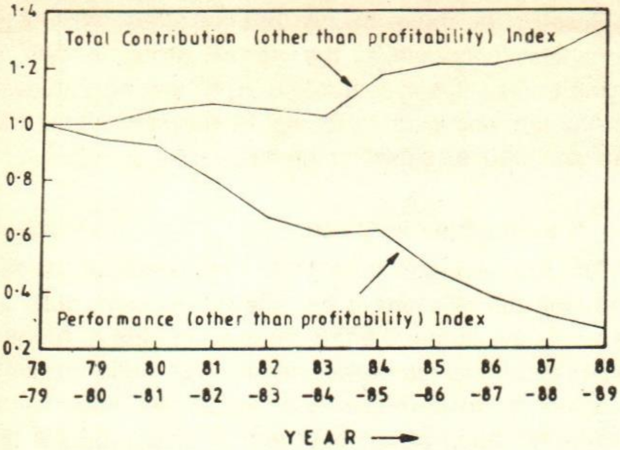

Fig. 3 Other than profitability performance.

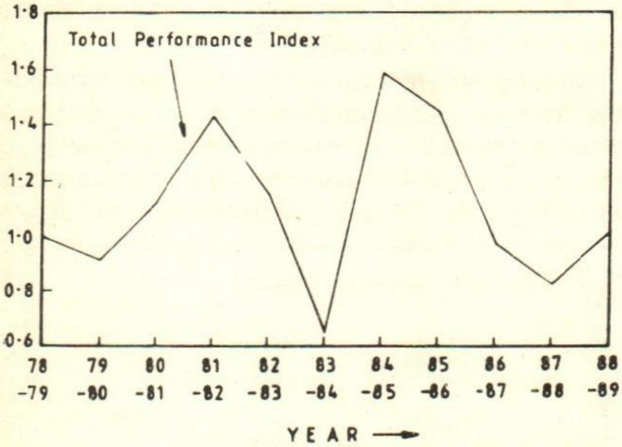

Fig. 4 Total performance.

the varying level of government levies and taxes, as well as the effectiveness of tax planning of the organization.

Investments towards community development and social welfare projects as well as the proportion of the employees belonging to the weaker section of the society and physically handicapped category have increased over the years as expected by the society (table 2). The organization under study has recognized the need to control the pollution level and protect the environment in line with the government policies and directives as reflected by the improving trend of pollution control index of table 2. The overall contribution to the 'society as the interest group' has been more or less on an increasing track, the ten year average being 16 per cent above the base level as shown in figure 2.

The total contribution (i.e. 'other than profitability index) based on the extent of contribution towards the three interest groups (i.e. the consumers, the national economy and the society) with equal priority attached to each group reflects on the whole an improving trend, the ten year average being 14 per cent above the base level (as shown in figure 3). However, such a performance level viewed in relation to the increased level of average net worth deployed, reflects a declining trend, declining more or less consistently over the years with an average performance for the ten-year period being 40 per cent below the base level. When the declining trend of 'other than profitability' performance is judged together with the improved level of profitability performance, the total performance of the organization reflects a varying trend (as shown in figure 4) with an average for the ten-year period being 10 per cent above the base year's performance.

Conclusions

The performance of an organization is not reflected by the profitability alone in terms of return on investments from the shareholders' point of view, but together with the impact in the areas of concern of other interest groups i.e. the consumers, the national economy and the society in general as the organization moves towards the path of profitability for its success and growth. The organization under study did well to improve its profitability performance over the years; however, in the pursuits of such profitability improvement, the rate of contribution to the areas of concern of other interest groups has declined with consequent erosion in the total performance of the organization. The measure of total performance would force the managers to reassess their strategies and priorities to optimise the return on investments but not at the cost of the consumers, the national economy and the society. Such a measure of total performance would not only facilitate the comparison of organizations belonging to different sectors but also would act as a change agent for the organizations to play a better role towards the development of the society at large. In the present study, equal weightages have been assigned to the different areas to assess the total performance of the organization. However, expectations from organizations belonging to different sectors may be different depending on the national plan priorities and as such, sector specific weightages may perhaps be more appropriate to judge the total performance of an organization.

References

Kolay, M.K. (1990), Some Studies on Human Resource Valuation at an Organizational Level - Performance Measurement Approach, unpublished Doctoral Dissertation, IIT, Kharagput.

Krishnamacharyulu, C.S.G. & Dakshina Murthy (1986), Research on Corporate Social Responsibility, Productivity, XXVII, 1.

The Tata Iron and Steel Company Limited (1980), Report of Social Audit Committee, Bombay.

Steel Authority of India Limited (1992), Annual Report as Social Accounts.

Developing Entrepreneurial Industrialists – An Alternate Approach

Thomas T. Thomas & K. Padmakumar

The evils of regional imbalances in economic growth and development in the current scenario of rapid industrialisation had prompted the Union Government to place more thrust on the Small Scale Industries (SSI) sector. Though, over the years, much support has been made available to the SSI, real benefits are not discernible due to various reasons including diversion of funds, mis-utilisation of resources, inadequate planning and consequent sickness of industries. Social scientists attribute this state of affairs to the 'lack of quality of the beneficiaries'. Since then "Entrepreneurship" in an individual to productively integrate resources and enhance economic growth has been given increased attention. Consequently, Entrepreneurship Development Programmes (EDPs), are being organised in India. But the results of EDPs have not been very encouraging. The authors critically analyse the present system for developing entrepreneurial industrialists with the purpose of evolving strategies for broadening the entrepreneurial base and its effective deployment for industrial growth.

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As a rapidly growing third world country, India has been taking careful and measured steps in its diverse developmental efforts. Over the years, the small scale industrial sector has been accorded adequate importance by various Governments in terms of financial and technical support. Institutional finance is available from State Financial Corporations, Industrial Development Corporations, and Commercial Banks. The Central and State Governments cater to the other requirements of the small industries, viz., licensing, infrastructure, incentives, technology, marketing and inter institutional tie-ups, through various departments and institutions. Even though there has been a great demand for availing such facilities, the real benefits have not been discernible, due to many reasons; diversion of funds, mis-utilisation of resources, inadequate planning and consequent sickness of industries, being a few of them. This state of affairs has been broadly attributed to 'lack of quality' of the beneficiaries.

Entrepreneurship Development Programmes

Social scientists were in search of that critical factor, 'Entrepreneurship', in an individual to productively integrate resources and enhance economic growth. During the sixties, through studies conducted within and outside India, David McClelland identified the 'need for achievement' (n-Ach) as the factor that instigates people to be entrepreneurial and venture into innovative and productive activities enhancing economic growth. This prompted the policy makers to place importance on Entrepreneurship Development. Consequently, training programmes for Entrepreneurship Development were initially conducted in a few selected centres in India. They were known as 'Entrepreneurship Training Programmes (ETPs)' and later as 'Entrepreneurship Development Programmes (EDPs)'. The training package was developed by the National Institute of Small Industries

Extension Training (NISIET), Hyderabad. Subsequently, the number of programme centres and EDPs increased at the national and regional levels.

Now, EDPs are generally conducted at the district level, both in urban and rural centres. As per the figures in the Annual Report on Industrial Development Bank of India (IDBI), 1992, they have supported 2393 EDPs of which 1995 were completed benefiting around 47000 potential industrialists. Considering that EDPs were being conducted since 1980, the total number of programmes completed till today would be around 2500, and the total number of persons trained, about 62500. The sponsors of these programmes include the State Directorates of Industries and Commerce, Industrial Development Bank of India, Industrial Finance Corporation of India, Industrial Credit and Investment Corporation of India, Commercial Banks and at times the Directorate of Sainik Welfare, Department of Science and Technology and State Financial Corporations. The programmes generally are of six weeks duration and may run for a period of two months. There are also programmes that run for periods ranging from one week to three months. EDPs are designed for various categories viz., women, ex-servicemen, Science and Technology Graduates, scheduled castes and scheduled tribes and assorted categories. With the objective of EDPs being creation of entrepreneurs and motivating them to set up industrial enterprises, they can specifically be called 'Programmes for Development of Entrepreneurial Industrialists'.

Selection of participants for EDPs is done by assessing the interests and competence of an applicant to become an industrialist. In general, persons in the age group of 19-45 years alone are selected. In the EDP, the participants are initially exposed to the investment opportunities in the region, the formalities and procedures to be adhered to, legal requirements, financial and other support available for setting up industries and to specific functional management topics. A market study, and industrial visits also form part of the EDP package. Acknowledging the significance of Achievement Motivation in moulding an entrepreneur, a comprehensive Achievement Motivation Training (AMT) is included. As a part of the programme, the participants are also helped to frame a project feasibility report required to be submitted for financial assistance from the Financial Institutions and the Government. Often, the programme organiser is instrumental in enabling tie-ups between the prospective industrialists and the supporting and financing institutions. The post-training support from the EDP conducting organisation extends for a period of one to two years, during which the participants are expected to blossom into entrepreneurial industrialists. The effectiveness of EDPs are gauged from statistics related to the number of programmes sponsored, programmes conducted, persons trained, project reports prepared, provisional registrations taken and units set up by the participants.

But, the results of EDPs have not been very encouraging with the national average, in terms of participants who have set up industrial units, placed around 10-15 per cen. of the total number of people trained. This could b indicative of the inadequacies in the present system fo development of entrepreneurial industrialists.

Critical Issues

Focusing on the human resource input to the present system for development of entrepreneurial industrialists, large number of individuals attending EDPs are not genuinely interested in becoming industrialists. Figure provides a diagrammatic representation of the same depicting the flow of human resource around EDPs. Th EDP, with its elaborate course content is perceived as 'one-shot capsule' which can convert a group of participants into entrepreneurial industrialists. As can b seen in Fig. 1, the participants usually are a mix of individuals with no specific career choice, those with som vague career choice, those with specified career objectives other than to become industrialists (informatio seekers) and also those who have clearly defined caree choice of becoming industrialists. Coming to participan selection, often, the claim by an applicant regarding hi intention to set up an industrial unit is the over riding facto which earns him a berth in an EDP. Unfortunately, th present selection process is incapable of spotting an possible bluff. Further, the organiser is left with th restricted choice of selecting the required number of pe sons from the available applicants.

Focusing on the human resource input to the present system for development of entrepreneurial industrialists, a large number of individuals attending EDPs are not genuinely interested in becoming industrialists.

Given this participant profile in terms of career obje tives, the resource limitations of the trainers to follow u each trainee beyond a certain period after the EDP ar the current level of effectiveness of the support system

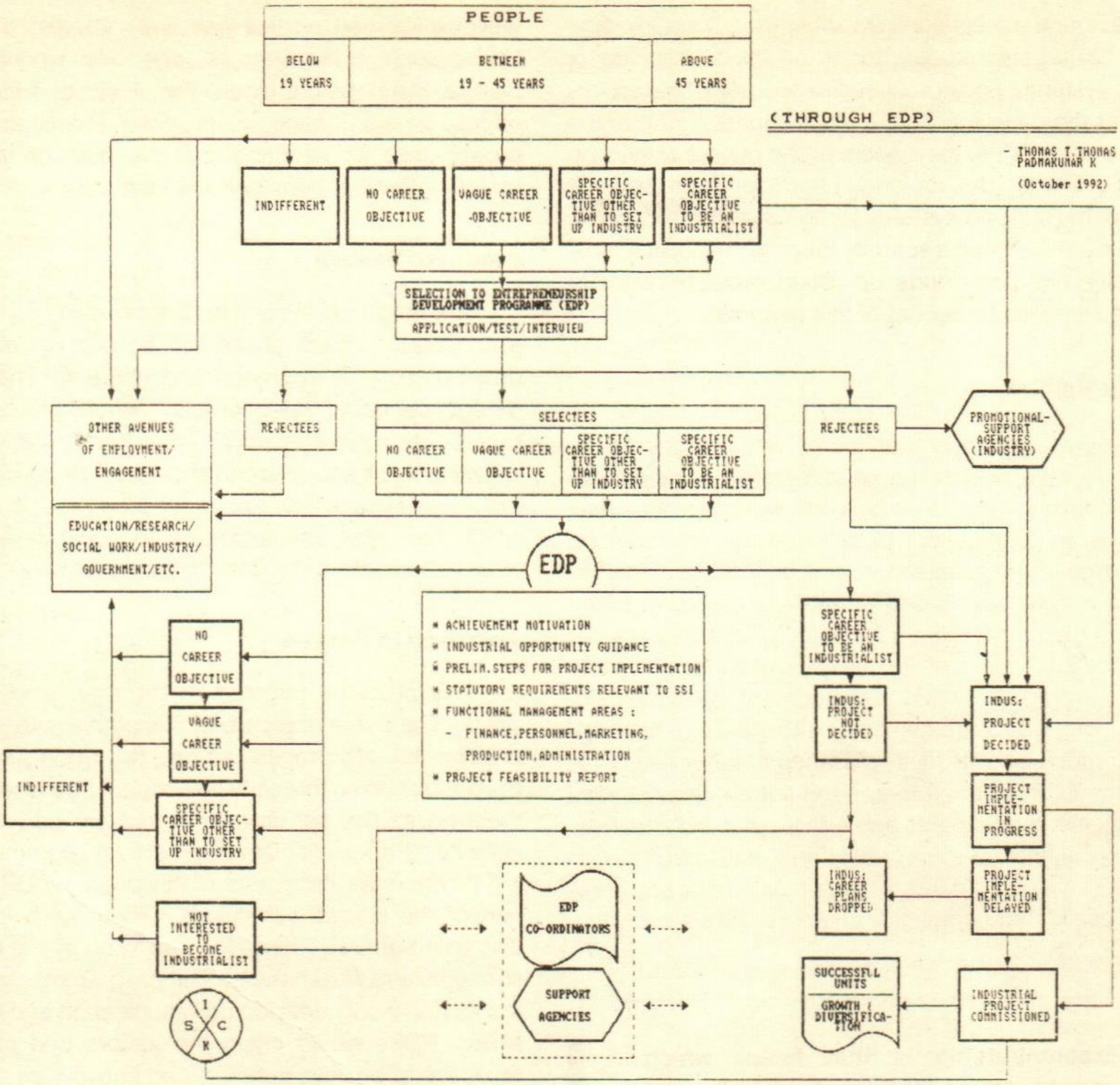

Fig. 1 Present system for developing entrepreneurial industrialists

for industrial development, only a small percentage of the trainees succeed in becoming industrialists. Others keep busy walking from pillar to post or withdraw creating an impression that the EDP is not effective. At the same time, many people start enterprises without adequate training. A number of units fall sick and this phenomenon is usually attributed to lack of entrepreneurial qualities and managerial competence among the owner managers.

As a result of low success rates in EDPs, the interest and involvement of the various sponsoring bodies of these programmes have waned. The interaction between the different agencies conducting these programmes are mostly limited to the extent of deciding on the number of programmes for the year and the centres where they are to be conducted and occasionally to the exchange of faculty members or experts for some sessions of the training. Otherwise, each organisation has its own approach, method and style of organising EDPs. Moreover, since the objectives of the programme and thereby the EDP package keeps changing with the organiser, the resultant outcome cannot be standardised and compared. Training programmes to develop Entrepreneur-Trainer-Motivators (ETMs) are also being organised by various agencies. But the exact slot for these ETMs are not clear as the present system for development of entrepreneurial industrialists is not adequately geared to accomplish the mission.

Studies on effectiveness of EDPs and promotional schemes often end up as a spread sheet of percentages. Studies of academic interest generally concentrate either on behavioural aspects or view them from a sociological angle. Managerial studies focus on the functioning of support systems. Some succeed in allocating the responsibility for the deficiencies or ineffectiveness, to either the participants of EDPs, the system or the people working in support systems. But, looking at the issue from the point of view of the support systems for industrial development, there has always been a scarcity for genuine applications. Eventually, everyone ends up listing problems without evolving solutions to get out of this quagmire.

Need for Rethinking

Entrepreneurship is that factor which urges an individual to take advantage of favourable situations by undertaking innovative practices with a concern for excellence and an assessment of self and the environment. One can be entrepreneurial in any walk of life. The absence of a solid and broad entrepreneurial base in the society is the prime reason for scarcity of achievers par excellence in all walks of life, leave alone industry. In this context, Entrepreneurship Development becomes significant. But, EDPs are identified with industrial development so much so that their relevance in other sectors is forgotten. EDPs attempt to append entrepreneurial traits to the selected participants and turn them to industrialists. This approach of 'Manuring the Fruit' has been disappointing as the participants in the stipulated age group will be of consolidated personality characteristics and diverse career objectives.

Entrepreneurship is that factor which urges an individual to take advantage of favourable situations by undertaking innovative practices with a concern for excellence and an assessment of self and the environment.

Doesn't this situation call for concerted action early enough to mould one's personality and build a broad entrepreneurial base in the society? Can't the behavioural inputs be put to better use, rather than confining them to the industrial sector alone? Shouldn't we think of having a broader perspective plan so that we have more of achievers in all spheres of life by the dawn of the 21st century? Now with the mission as industrial promotion, shouldn't we think of a system in which entrepreneurs will come forward on their own to take up career in industry as industrialists. Efforts for developing industrialists could then be focused on this genuinely interested segment Under such circumstances, agencies working for industrial development would find it easier to focus thei. efforts. In this context, we propose a result oriented approach that would bring out the best of the human resource that our country is blessed with.

Proposed System

The proposed system is conceived in four phases, in a continuum. Each phase has its own specifically laid down objectives, approach and content. These stages though operating independently, would interact and integrate into a synergic whole. (See Fig. 2). An Apex Body will have to be set up at the state level to co-ordinate the activities of the different phases. Ideally, an organisation which has adequate exposure to such developmental efforts should hold the reins of this system.

Approach in Phase I

This phase is targeted at the age group of 12-15 years. The prime objective of this phase is to inculcate a positive thought process among this young segment of the population as this early adolescent age is regarded by theorists as the apt time to mould an individual's personality. 'Personality Development Programmes (PDPs)' will be the main instrument of this phase. PDPs will form part of the course curriculum. They will help each individual to appraise himself so as to be aware of his own strengths and weaknesses. The programmes will provide inputs that would develop communication and leadership skills. PDPs would orient the juniors and make them receptive to positive criticism and knowledge that will be imparted in the subsequent phases.

PDPs will be conducted in schools by the available teaching staff. These teachers will have to be trained and equipped for this new role which they will have to play along with their other regular duties. 'Student Trainers' Training Programmes (STTPs)', meant for teachers of middle and high schools will be organised by the Apex Body at the state level. The STTPs will be coordinated by professionals in Behavioural Science and with adequate experience in Training and Extension.

It will be good if the Government can frame a scheme and earmark funds, under Human Resources Development (HRD) efforts, specifically education, so that this phase takes off as an ongoing process. Extreme care will be taken to evolve a standard package and control mechanism to ensure that these efforts at different centres do not become haphazard.

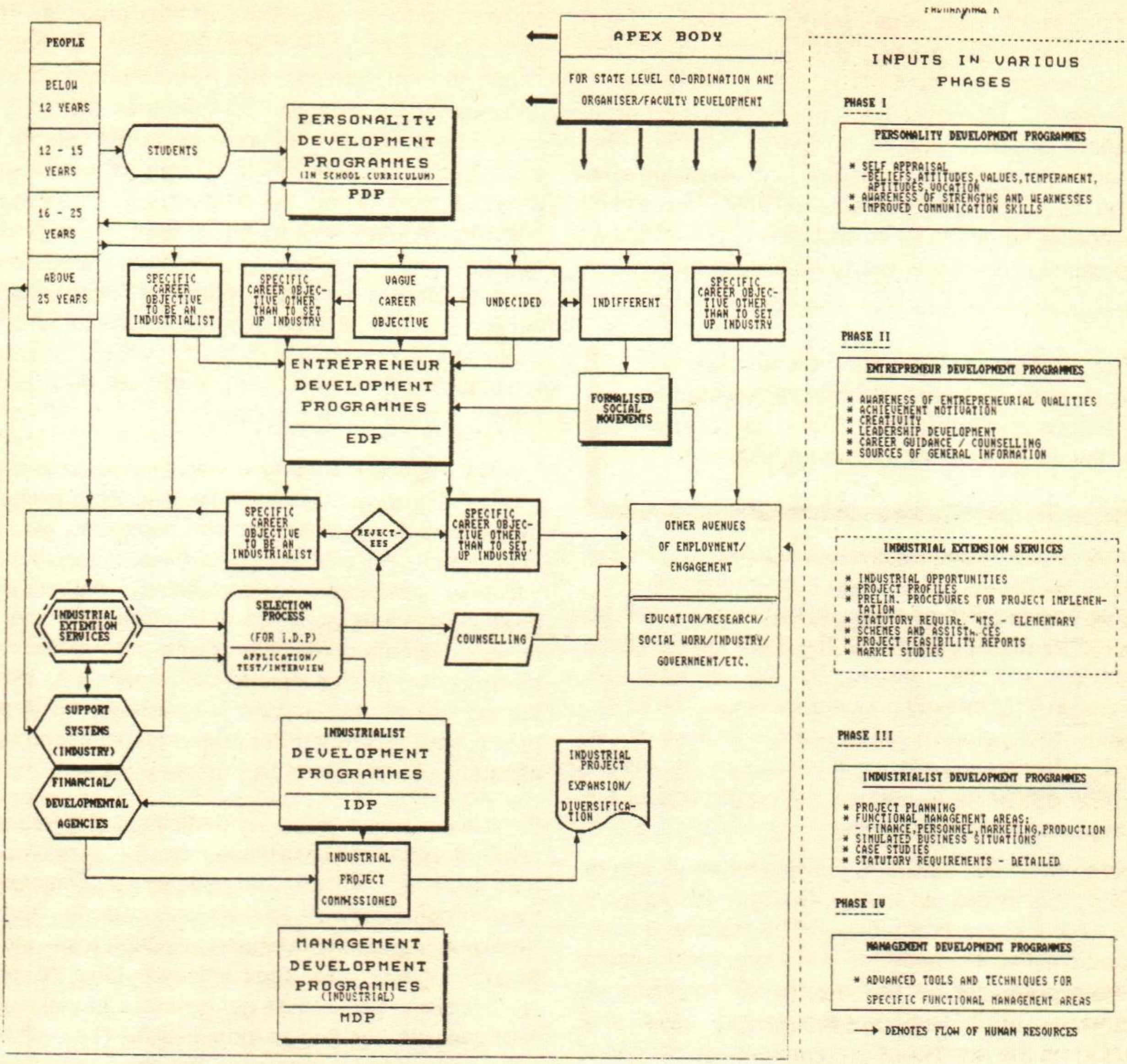

Fig. 2 Proposed system for developing entrepreneurial Industrialists.

Approach in Phase II

Phase II is aimed at individuals belonging to 16-25 age group only. The objective of this phase is to go deeper into an individual's personality and stimulate in him the entrepreneurial attributes. It will instill in him the need for Achievement (n-Ach). Also, the spark of self understanding kindled in Phase I will be amplified in the Phase II, so that, the participants perceive themselves in a better light with respect to their strengths and weaknesses.

The effect of Phase I will be felt only in about three to five years after its commencement. The students who are the focus of Phase I, after having gone through the PDPs, can be expected to be of more mature and consolidated personality characteristics who would also have a broader perspective about self and their role in the well being of the society. We do not ignore a sizeable population falling in the '16-25' age group who could not pass through the I phase as it does not exist in the present educational or entrepreneurship development systems. The restriction in terms of age is because, it will be difficult to remould the behavioural traits of people above this age group as they are likely to have consolidated personality characteristics.

In Phase II, programmes will be designed exclusively for Entrepreneur Development and will be called 'Entrepreneur Development Programmes (EDPs)'. EDPs will be conducted at taluk level by voluntary organisations/non-governmental organisations (NGOs). They would differ from the existing programmes, in that no industrial management input will be given at this level as is done at present. Moreover, each trainee will be exposed to a variety of career options, including industry. The motivated individual could choose from these options based on his background, interests and aptitude and then can channelise his efforts for its accomplishment. A scientific approach to career counselling will be resorted to.

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Entrepreneur-Trainer-Motivators required to carry out this work, will be trained through 'Entrepreneur-Trainer-Motivator Training Programmes (ETMTPs)' that will be conducted by the Apex Body at the State Level. These programmes will be conducted by professionals specialised in ETM training (trainers' training). The ETMs, preferably, professionals in behavioral science social work with adequate experience in training and extension, will also be a position to counsel the participants of the Phase II as and when need arises.

There will be any selection process for admission to the EDPs. It is envisaged that all aspirants should get a chance to attend the programme. The state level apex body coordinating the activities in the proposed system will have a computer backed mechanism to queue all applicants. On a first-come-first-served basis and depending on the number of programmes targetted in a year, every aspirant will be informed of his turn to participate in the EDP. There is a possibility of individuals not availing this facility and proceeding to pursue a career in industry or other sectors. Indifferent individuals are to be taken care of by other formalised social movements.

These programmes may be put under HRD efforts by the Government, specifically 'Training and Extension', and funded under it. Care should be taken to evolve a standard package and control mechanism for this purpose. The output of Phase II can be classified into two groups: Entrepreneurs with defined career objectives to become industrialists and Entrepreneurs with career objectives in other sectors.

Approach in Phase III

Phase III, predominantly an industrial development phase, is targeted at people who have taken convincing steps towards implementation of their projects. The objective is to enhance their knowledge base for pursuing a career as an industrialist. This phase will operate through 'Industrialist Development Programmes (IDPs)'. These programmes will be conducted at district centres by the state level apex body either general or sector specific areas. Specific inputs will be given on project planning, statutory requirements to be adhered to in setting up industrial units, functional management areas and behavioral aspects relevant to industry. These prospective industrialists will also be exposed to simulated business situations. Every aspirant to the IDP will get support from the Industrial Extension Services that will be a vital component in the proposed system.

The 'Industrial Extension Services' assume a critical role in the proposed system. These services will be made available to every individual who aspires to become an industrialist. An extensive data-base, incorporating the industrial investment opportunities, marketability of products/services, schemes of financial and other assistance of various bodies along with the procedures and formalities for project inplementation will be an inevitable component of this service. Assistance in preparing project feasibility reports for project planning and financial assistance will also form part of this service.

It is envisaged that every participant of IDPs must get financial and other assistance from the concerned support systems. Hence, the selection of participants to these programmes will be meticulously done. Apart from qualifying in properly designed selection tests and structured interviews, the applicants will have to produce credentials to prove their genuineness in claiming their willingness to become an industrialist. They will have to submit their project proposals that can be prepared with assistance from the Industrial Extension services. This will be appraised by a Board that will be constituted for selection of persons to the IDPs. The board will be constituted with officials and experts drawn from all relevant support systems as applicable to industries. Persons who are rejected by the Selection Board will either be directed to submit fresh proposals or be provided counselling assistance and guided to seek employment or engagement in other available avenues.

The proposed system suggests adequate linkages among these divergent efforts. The selected individuals to the IDPs will be put to a rigorous one month training that will be equipped with required industrial management expertise. Simultaneously, the support systems for industrial development must be geared to carry out detailed appraisal of project proposals from the participants so as to provide all required infra-structural and financial support. A single window clearance need be ensured. Thus, project implementation would commence on completion of the IDP. We do not ignore the possibility of individuals directly approaching the Industrial Extension Services and subsequently the support systems, for getting their projects commissioned. Figure 2 also depicts the eventuality of these individuals being directed to pass through the IDP channel. IDPs may be funded by the All India Financial Institutions and Commercial Banks and State Directorates of Industries and Commerce, specifically under Extension. The programmes will be coordinated by professionals in Management/Engineering with adequate experience in Training and Extension. The monitoring of IDPs need be meticulously done by stipulating standards for output in terms of number of industries set up as a result of the programme and the corresponding value additions in the sector.

Approach in Phase IV

The objective of this phase is to provide inputs for scientific management of industrial enterprises. Efforts will also be made to help evolve management systems for better functioning of industrial enterprises. This phase is optional to the industrialists. Management Development Programmes (MDPs) will be organised for this target group and will be priced. The focus of these programmes will be on specific functional management areas as relevant to the various industrial sectors. These programmes organised by the state level Apex Body will be coordinated by professionals in Management and Engineering with adequate expertise in the concerned areas.

The stress here, will be on the development of managerial skills of individuals and management systems in the enterprises from which the participants come from. The programme will expose the industrialists to advanced techniques and tools for effective management of their enterprises. It will also look into the futuristic options available for capacity expansion or diversification of their existing ventures. Moreover, these programmes will be platforms where the doers, achievers and thinkers can come together and interact so that optimal solutions are arrived at for issues and problems identified by them.

> **These programmes will be platforms where the doers, achievers and thinkers can come together and interact so that optimal solutions are arrived at for issues and problems identified by them.**

Mechanism for Co-ordination

The performance of this system would largely depend on the effectiveness with which the programmes are planned, implemented and monitored. Extreme care will have to be taken to ensure good quality of work at every stage. The Apex Body that is suggested at the state level will have a prominent role in over-all planning, monitoring and control of the activities carried out at each level in the system.

Conclusion

> **Entrepreneurship is a way of life; a thought process. To bring any sustainable change, effort has to be more broad based.**

In the ultimate analysis 'Development of Entrepreneurial Industrialists' is not an easy proposition. Neither it is what we have so far taken it to be. It cannot be a simple process of conversion, overnight, of behavioral attributes that have consolidated over a life-time, or may by generations. Nor can we restrict entrepreneurship to water tight compartments of industry or business. It is a way of life; a though process. To bring any sustainable change in this aspect, effort has to be much more broad based. It has to start earlier too. Clinging on to our present mode for development of entrepreneurial industrialists is not going to bring in better results. But results, we need. That calls for a definite shift in our emphasis and approach. The system we have proposed will provide a broad frame work for devising action plans in this regard. Funds and expert manpower at present on Human Resource Development is not as productive as we would like it to be. Hence, it is a matter of policies to fix priorities and evolve financing plans for this vital cause.

Acknowledgement

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Feature

Quality Excellence for Productivity Improvement

Pradeep K. Chatterjee

Productivity can be increased either by minimising inputs or maximising outputs. Maximising output commercially means maximising the sales turnover of the Company rather than the production turnover. In today's highly competitive and complex business environment, sales turnover can be maximised only by customer satisfaction/delight. Customer acceptance of a product/service is the indicator of successful output. Instead of producing more we need to produce better. Focus on customer should be the central tenet for any business. This paper illustrates the need to invest in customer satisfaction vis-a-vis TQM.

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Productivity means different things to different people. Some view productivity as nothing more or less than the productivity of labour, i.e. it is the motivated employee who will bring about the necessary improvements in productivity. There are others who see it as an issue of capital productivity reflected in such indices as Incremental Capital Output Ratio (ICOR). Then again there are some who consider it as a matter of technology upgradation. Another school of thought looks at productivity as a function of management.

The principal cause for the failure of many a well-intended scheme of productivity is the fragmented perception. The efforts expended in any one direction or specific area without considering the overall needs will not bring about the desired results. Productivity improvement, therefore has to encompass all the above areas and everybody in the organisation has to become aware of it and must participate in bringing about continous improvement. In order to ensure purposeful direction of energies for productivity improvement, we need to adopt a comprehensive definition of the issue. In today's context of increased uncertainities and complexities, intensified competition and increasing customer sophistication, the appropriate definition of productivity is in lerms of most effective use of all the available resources and improving quality for maximising customer/client satisfaction or customer/client delight. This definition shifts the focus of effort from the elements of productivity to the goals of productivity. It takes in its sweep all the constituent aspects such as: product design, features and reliability, cost of production, pricing policy, marketing strategy, after sales service, continuous feedback on customer reactions etc. It is the adoption of this definition of productivity and its pursuit as a cult which is responsible for the success of Japan as the conquering Caesar of international markets.

Quality and productivity are not trade-offs. Productivity actually aims at producing better and not necessarily producing more. Instead of competing they must complement each other. With high quality we will have better output, fewer rejects, less rework, less wastage, lower cost and hence higher productivity. Quality and productivity, therefore, are just two sides of the same coin. Many countries in Asia which stood lower than India; Japan, South Korea, Taiwan, Singapore, Hong Kong and lately even Thailand, Malaysia and Indonesia have taken giant strides in the industrial scenario of the recent decades. Inspite of the reforms, India's overall ranking went down from 10th to 11th position in 1992 amongst the emerging nations on the scale which measures a nation's competitiveness (table 1).

Table 1. India's Competitiveness in the World

Overall Ranking		A	B	C	D	E	F	G	H
(1)	1 SINGAPORE	1	1	1	1	1	1	2	1
(4)	2 TAIWAN	3	3	4	7	6	3	1	3
(2)	3 HONG KONG	5	2	3	2	3	2	4	5
(5)	4 MALAYSIA	6	5	2	3	5	4	6	4
(3)	5 KOREA	2	6	6	8	2	5	3	2
(6)	6 THAILAND	4	4	5	6	12	6	7	6
(7)	7 MEXICO	9	7	7	5	8	8	10	7
(-)	8 S. AFRICA	12	10	10	4	7	7	5	14
(-)	9 VENEZUELA	11	8	9	9	9	9	11	8
(8)	10 INDONESIA	7	13	8	12	11	12	9	11
(10)	11 INDIA	8	14	11	11	13	11	12	9
(9)	12 BRAZIL	13	12	14	10	4	10	14	12
(-)	13 HUNGARY	14	9	12	14	10	14	8	10
(-)	14 PAKISTAN	10	11	13	13	14	13	13	13

Ranking based on: A — Domestic Economic Strength, B — Internationalism, C — Government, D — Finance, E — Infrastructure, F — Management, G — Science & Technology, H — People
Overall ranking in: (1991) 1992
Source: World Competitiveness Report, 1992 (World Economic Forum)

The Quest For Quality

To build a product/service into a strong profitable asset of a company, everything associated with it must be of quality at all levels. Quality is a way of doing business for customer satisfaction. In the seventies, quality was just the responsibility of the quality-control department. The emphasis was on quality tools and techniques such as control charts and lot inspections/checks. The top management was hardly even directly involved in quality-related matters. The eighties saw a revolution in the attitude to quality, and in the role and responsibility of the quality-control manager. Top management executives began to realise that quality was something they had to commit themselves personally. The quality manager was thus given increased responsibility in advising the company on these matters, in training and in introducing quality ideas to departments other than manufacturing. While quality-control programmes in the eighties were geared towards manufacturing, the nineties will see an emphasis on quality in all other aspects, be it marketing, finance or personnel. The 1989 Malcom Balridge National Quality Award (MBNQA) winner David T Kearns says Quality is meeting customer requirements. It is what the customer says, perceives, and believes. It means giving him what he wants. It should be present in the process as well as in the product/service. Product/service quality can be defined as the total composite characteristics of marketing, engineering, manufacturing and maintenance through which the product/service in use will meet the expectations of the customer. It depends upon whether the features of the product and services are in line with what the customer expect.

Quality is increasingly becoming a source of competitive strength in world economy. The winners of tomorrow are those who are today paying attention to quality and customer service. Organisational survival and growth relies heavily on its ability to successfully and economically produce and deliver high quality products and service thereby satisfying the customer to the maximum. The need for quality management and upgradation has been accepted by all, but instituting the changes is not easy. It involves a cultural change, extensive training for both managers and workers and constant monitoring at every stage. The process seems to require a commitment from the top. That is the international thought projected through ISO-9000.

The winners of tomorrow are those who are today paying attention to quality and customer service.

Total Quality Management (TQM)

As leading world class organsations raise their standards, the level of quality expected by the customers also continue to increase. In response, a number of organisations world wide are adopting new management techniques. Total Quality Management (TQM) is the most attractive among all the quality improvement methodologies. It seeks to improve product quality and increases customer satisfaction by restructuring traditional management practices. Winners of the highest TQM award – The Deming Prize in Japan and the Baldrige Award in the US – include the most respected and successful corporations in their respective industries: Toyota, Matsushita, Canon, Motorola and Federal Express.

TQM is based on four powerful concepts; focus on customer, employee involvement, mastery of processes and teamwork. "Focus on customers" is the nucleus of TQM. Customers are the source of all the revenue that flows through the organisation. TQM is not a set of problem-solving techniques, nor is it quality circles. It implies the reshaping of an organisation through congruent changes by incorporating Quality Management System conforming to ISO 9000 standards in all related areas be it marketing, design, product development, procurement, manufacturing, inspection, sales and distribution, technical assistance and maintenance etc. An integrated organisation wide programme of change is required.

TQM is not a set of problem-solving techniques, it implies the reshaping of an organisation by incorporating Quality Management System.

The application of TQM is unique to each organisation. However, over the past 4 years, several organisations in the US have built their TQM model around the criteria used in Malcolm Baldrige National Quality Award which is of more recent origin as it was instituted in 1988, with rewarding results. Increasingly, organisations view the criteria outlined in the MBNQA as useful diagnostic tools for evaluating the effectiveness of their own management practices. The main criteria for MBNQA are seven aspects and their weightage is as follows:

Criteria	Points	Weightage
Leadership	100	10%
Information & Analysis	70	7%
Strategic Quality Planning	60	6%
Human Resources utilization	150	15%
Quality Assurance of Products & Services	140	14%
Quality Results	180	18%
Customer Satisfaction	300	30%
Total Points	1000	

Investing in Customer Satisfaction

This is the most heavily weighted category in MBNQA. The various elements of customer satisfaction with their individual weightage as outlined in MBNQA are as follows:

Customer satisfaction element	Points
Determining customer requirement and expectations	30
Customer relationship management	50
Customer service standards	20
Commitment to customers	15
Complaint resolution for quality	25
Determining customer satisfaction	20
Customer satisfaction results	70
Customer satisfaction comparison	70
Sub Total	300

The key issues for achieving customer satisfaction are:

- Make customer satisfaction a central focus at the corporate level.
- Monitor customer needs, desires, expectations and attitudes.
- Involve upper management in monitoring and understanding the customer.
- Focus efforts on training and motivation of front line service providers and management so that they know how and why to deliver services.
- Expose personnel to a corporate-wide perspective.
- Openly share information about the corporation and the need for service.
- Show support for, and faith in front line service providers.
- Set high measurable standards on quality service (aim for perfection).
- Provide goals, and feedback on employee performance to standards.

Organisations who want to be successful in future should focus on their customer by doing the following:

- Do not assume customer needs. Find out? (See service from the customer perspective).
- Stay in touch with the customers. (It will help in recognising service opportunities and developing a closer partnership with the customer).
- Invest in customer research.
- Use appropriate customer technology. (Technology is only valuable if it addresses customer needs).
- Communicate customer desires to personnel.

- Try to measure customer satisfaction which is evident by minimum/zero rejections, zero defect, zero complaints, repeat order, number of accounts gained/lost, increase in purchase volume, increased sales turnover, increase in market share, profit increase, customer loyalty etc.

In a total quality organization, customer needs are to be constantly monitored to improve products and processes to meet their requirements. New products/services are to be developed anticipating future requirements of the customers. To do so, there should be a close involvement of marketing, design and development, production and servicing personnel and other wings of the organization as outlined in ISO – 9004.

The organization has to gain customer trust. The obvious benefit is customer satisfaction evident by a long term selling relationship. Sales personnel can emphasize his availability and ability to serve customer by saying "call us anytime for anything that you need". This type of statement has to be supported by devices like hot line, electronic mailing, telex, fax services, or even sales call. There is a need to have intense and extensive interactions with valued customers. The organisations should pursue things not just for customer satisfaction but for customer delight.

Why India needs TQM ?

TQM has still not become a very wide spread practice in India largely because of the comparatively low levels of competition. Rarely has effective competition existed in core industries such as power, petroleum or steel. One of the negative fall-outs of limited competition, is the existence of a perception that firms can get away with the production of goods and services that they like to produce and deliver, rather than what the customers are actually looking for.

In markets that are not only teeming with competitors, but where the bargaining power of the customer is also high, obviously TQM holds the key to success.

The stimulus for Indian industry to look towards TQM as a means to become more competitive has come from the need to step up the export efforts. The realization has at last dawned that we must "globalise" or perish in the economic arena. The long term viability of a company will depend upon its ability to export. Since exports depend on quality, successful companies will have to be more customer driven and go well beyond their present standards. The world has seen Japan's rise to economic heights solely as a result of developing a high degree of overall excellence. The Americans, realizing that the economic success of Japan is largely attributable to the tremendous commitment to the needs of the customers, consequently have geared themselves up to achieve this objective and maximize their potential through TQM. In markets that are not only teeming with competitors, but where the bargaining power of the customer is also high, obviously TQM holds the key to success. Due to this reason, all of a sudden, there is a great rush to get ISO–9000 certification which has become a pre-requisite for supply in the global market. The US and Japan with their highly developed standards initially tended not to take this standard seriously. But realising that they could be thrown out from the huge EEC market, they are now working towards adopting their system to fall in line with the ISO-9000 series. The EEC market, with its 350 million population, represents the largest single trade market in the world far ahead of the US which has the population of 250 million and Japan which has 120 million. ISO-9000 certification is the passport to the global market. The registration is not really a Government regulation but a very important customer regulation. The organisations which want this passport will have to prepare a quality manual which defines the contractual, functional and technological requirements from all quality activity that will ensure that the product, process, service or system is fit for its intended purpose.

Several companies in the engineering industry, like Sundaram Fasteners and Sundaram Clayton, Flakt, Kirloskar group of companies, Widia, Godrej and Boyce, IFB, Crompton greaves, BHEL, BEL, MECON, MUL etc.; have adopted TQM and as a result moved to the fore-front in a highly competitive industry. This will help them to compete more forcefully in the world market. Many others have just made a beginning. However, Indian industry have a long way to go – owing to frozen mindsets. Are our processes flexible enough to accept change? Can Indian companies set standards based on changing customer needs of global market? □

Feature

Evaluating Food Production Alternatives – A System Dynamics Approach

Purnendu Mandal

For strategic reasons, food production scenarios under different policies for a country need careful investigation. This enquiry could be facilitated by a system dynamics model which has the ability to integrate the knowledge from the diverse areas of food production system in its formulation and to analyse the consequences of alternative policies. This paper describes and demonstrates the usefulness of a system dynamics based food production model for a developing country with special reference to Indian agriculture. The internal mechanisms of land development (and distribution) and crop yield have been described detail. Five policies have been tested with this model and their implications explained.

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The major inputs to food production system are land, labour, capital and technology. Various studies on food production have attempted to relate these inputs empirically (Acharya, 1992; Bhatia, 1983; Dev, 1991; Horie, Yajima and Nakagawa, 1992). Virtually, there is no evidence of a study which considers the cause-effect relationships among the variables determining food production at the national level. Viewing national agriculture from a systems perspective and bringing in systems concepts to the mechanisms of food production one can achieve a deeper understanding of the food production system. As a first step towards determining the food production one can assume that the production is dependent on the amount of land and the yield per unit of land. Figure 1 presents a simple relationship between land, yield and output. But, normally a number of attributes are associated with land. For example, it can be a waste land or cultivated land, irrigated or unirrigated, owned by big farmers or small farmers. Similarly, the yield from a plot of land will depend on the amount of various input applied into the land.

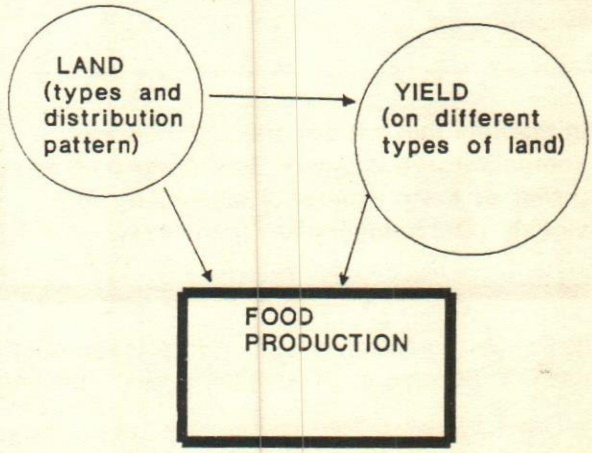


Fig. 1. Land and Yield in Food Production

There are other influences which are normally regarded external to the food production system, but which continuously affect the operations of this system. The most important factor which influences land development (land creation and irrigation) and, ultimately, the food production is investment (as shown in Figure 2). The overall causal loop diagram operating through investment in land development and farm inputs, food production, agricultural output, savings and investment determines to a large extent the behaviour of national food situation. As food production increases more savings will be made (by way of curtailing food imports) and more investments can be made in land development and irrigation which improves the prospect of more food production in the future. The investment in agriculture is decided externally by the finance system, but how this investment is distributed among the activities is internal to the food production system.

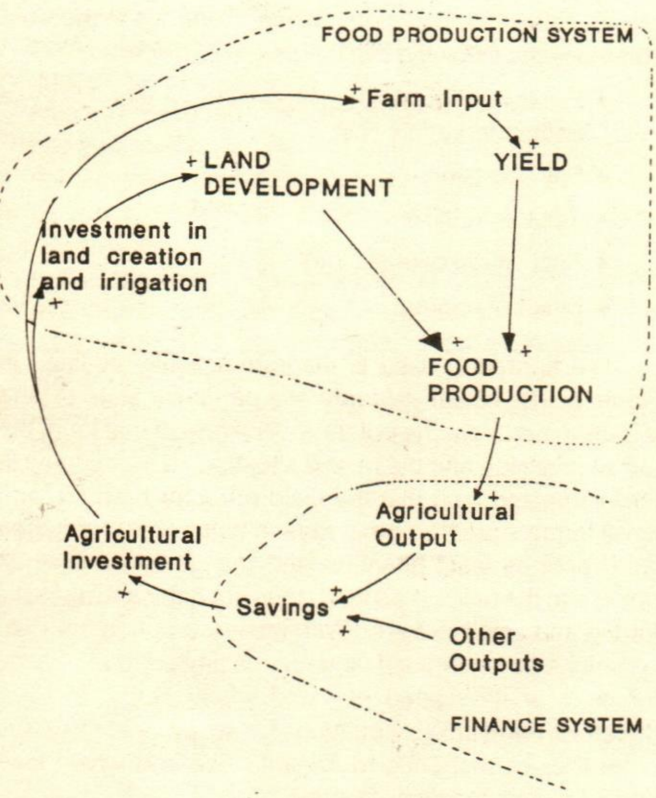


Fig. 2 Overall Influence of Food Production System and Finance System

Land Development

The Development of land can be treated as a gradual process which follows two basic steps. First, the cultivable waste land is converted into unirrigated land and then, unirrigated land is upgraded to irrigated land. The process is controlled by three rates associated with various states of land as shown in Figure 3.

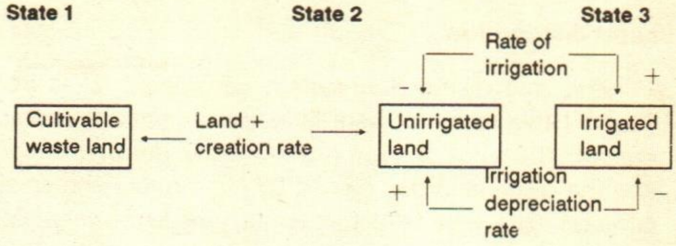


Fig. 3. Mechanism of Land Development

The benefits of land development by land creation and irrigation in India has accrued largely to rice and wheat cultivation. Over the 30 years period from 1950 to 1980, about 89 per cent of the increase in total land under cultivation has been accumulated to rice and wheat. An additional 25.4 million hectares was brought under food cultivation since 1950 out of which 22.6 M.Hec was allocated to rice and wheat crops (Directorate of Economics and Statistics, 1978; 1980). The production of other cereals and pulses, occupy over 50 per cent of the total cultivated land, but the increase in the cultivated land in them has been a mere 11 per cent since 1950. For practical purposes it is assumed that the levels of land under other cereals and pulses remain constant and any increment in land availability is attributed to rice and wheat cultivation.

The land creation rate is primarily dependent on the investment and the cost per unit land conversion. However, the process of land conversion also involves some delay and it takes a significant amount of time from the instance of capital investment to actually realising the converted land. Irrigated land increases by the rate of irrigation but is depleted due to degradation to unirrigated land. Unirrigated land also increases by land creation but decreases by the rate of irrigation. Similar to the land creation rate, the rate of irrigation depends on the capital investment and the cost of irrigation per unit land. Again, there is some delay involved in the process of irrigation. It is assumed that until two years have passed from the start of an irrigation project no capacity is made available.

The cost of irrigation is related to the level of irrigation. The level of irrigation is defined as the proportion of cultivated land (irrigated and unirrigated together) brought under irrigation. As the proportion of irrigated land increases further irrigation becomes difficult and costly. Like any physical process irrigated land also gets degraded in course of time. It is assumed that the benefits from an irrigation project last for about 40 years. Irrigation depreciation rate, here, is directly related to the level of irrigated land with a depreciation period of 40 years.

Land distribution

The land distribution pattern considered takes into account two states of here land (i.e. irrigated and unirrigated), the types of crop produced (i.e. rice and wheat) and the ownership (i.e. owned by big farmers and small farmers). These three factors (state, type and ownership) help to identify a plot of land to belong to one of the eight categories as shown in Figure 4. There is a 3-stage local sequence in determining the final pattern of land distribution and the stages coincide with land development, cropping pattern and the ownership respectively. The mechanism by which the magnitudes of land in these final eight categories change depends on the land development activities (rate of irrigation, depreciation and land creation), the transfer of land across crops and the transfer of land ownership, are shown in Figure 5.

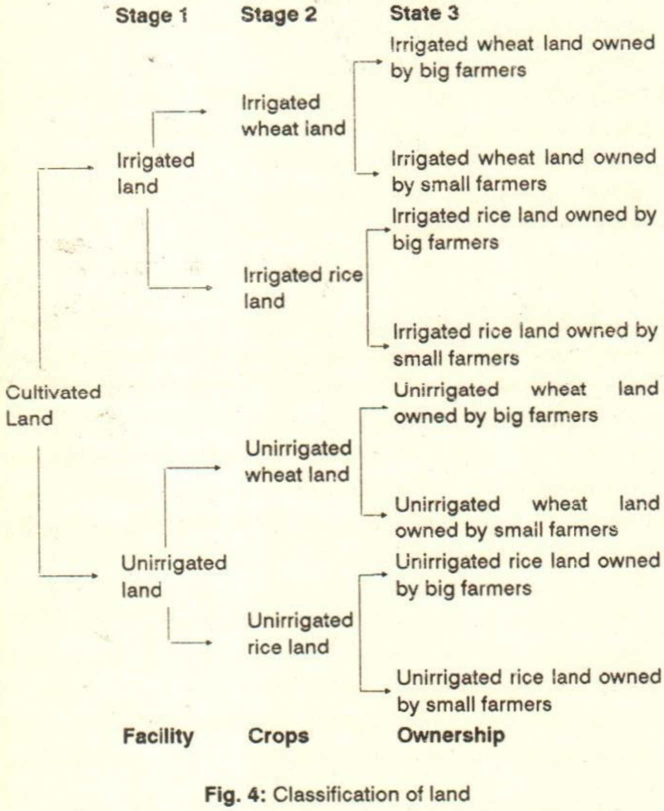


Fig. 4: Classification of land

The rate of transfer of land ownership is the resultant of land transfer from small farmers to big farmers (which depends on the purchasing power of big farmers) and the transfer of land from big farmers to wage earners by Government Regulation. The amount of land purchased by big farmers is determined by the amount of money they can afford to buy land and the cost of land. Whereas, the forceful land transfer from big farmers to wage earners by the imposition of land ceiling act depends on the amount of land held in excess of their legitimate share. The amount of excess land is calculated from the actual amount of land in position and the permissible amount derived from the number of households and the land ceiling. It is assumed that a household with 5.5 persons in average can hold at the most 4 hectares. Though the Government of India has introduced land ceiling act for a long time, it has been, in practice, grossly misused and has become ineffective.

Mechanism of Constructing Crop Yield

The land under rice and wheat cultivation has been differentiated into eight states. Therefore, it is necessary to build yield equations consistent with these eight land states. The construction of the yield equations has been very elaborate and the constituents of the equations preserve their physical significance. To arrive at the yield equations the following five inputs are considered:

- Fertility of the seeds: high yield variety (HYV) or traditional variety (TV)
- Soil condition
- Input of fertilizer
- Application of pesticides
- Effect of rainfall.

The approach used is diagrammatically outlined in Figure 6. The actual yield rate of a particular state of lan is determined from the potential yield rate of that land, th use of pesticide and the rainfall situation. It is assumed in the unirrigated land that the yield rates for both big and small farmers are the same, reason being that unirrigated land receives least attention and the amount of input going into the unirrigated land does not differ substantiall for big and small farmers. With this assumption the yield equations for unirrigated land can be limited to two; one for each of unirrigated rice and wheat land. In total therefore, there are six equations for actual yield rates; th other four corresponds to irrigated rice and wheat land owned by big and small farmers.

Potential Yield Rate

The potential yield rate is determined by the fertility of seeds, fertility of soil and fertiliser use. Logically, the potential yield of a plot of land is composed of tw components: the base yield rate and the yield expected from the use of fertiliser.

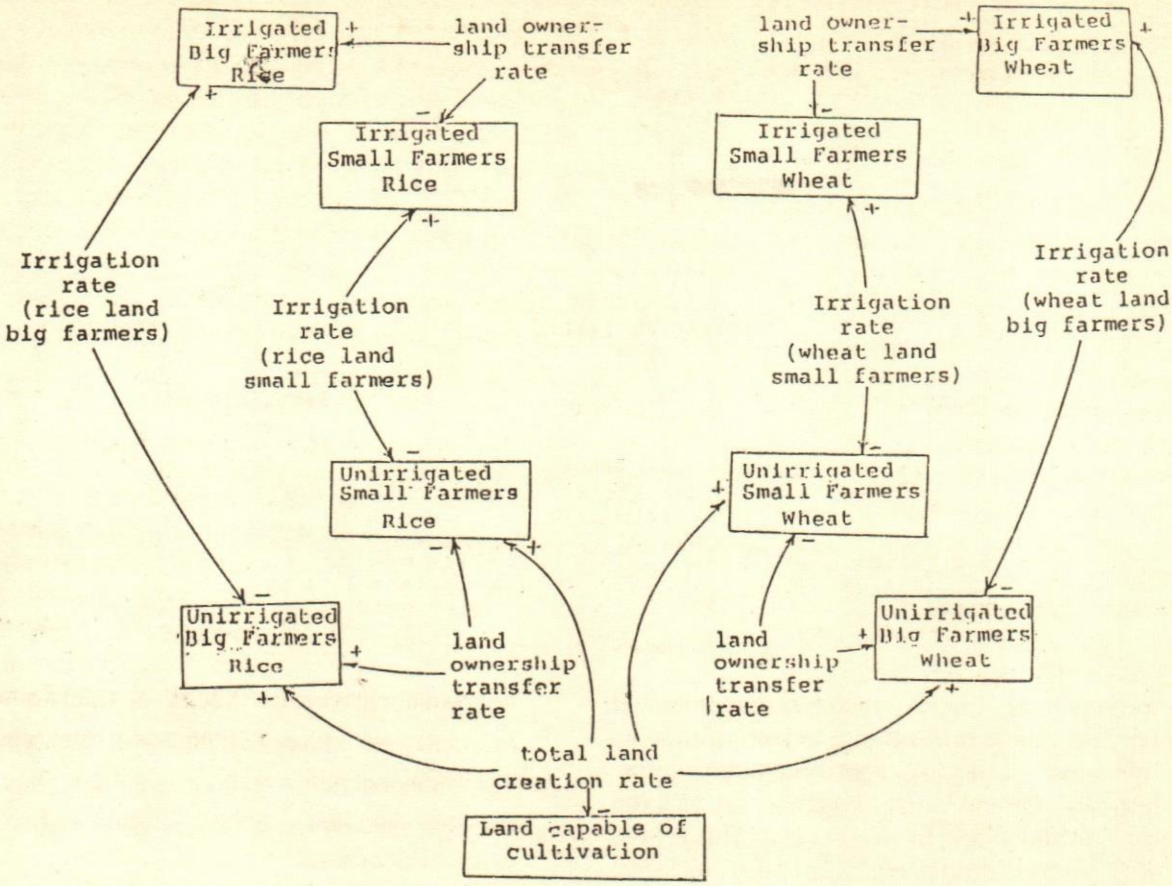


Fig. 5 Land Development and Distribution

Thus,

$$PYR = BYR + EFAR * YRPUF \quad (1)$$

where,

PYR = potential yield rate (kg/hec)

BYR = base yield rate (kg/hec)

EFAR = effective fertiliser application rate (kg/hec)

YRPUF = yield response per unit fertiliser (Kg/Kg)

Base Yield Rate

Base yield rate is the average yield from one hectare of land depending on the genetic characteristics of the high yield variety (HYV) and the traditional variety (TV) seeds and their distribution pattern. It is the yield that can be achieved without the influence of any other factors and with present state of technology. Two factors which effect base yield rate are genetic yield rates and the distribution of HYV and TV seeds.

Thus, the general form of the base yield is:

$$BYR = YRTV * PATV + YRHYV + PAHYV \quad (2)$$

where,

BYR = base yield rate (kg/hec)

YRTV = yield rate of traditional variety seeds (kg/hec)

PATV = proportion of area under traditional variety seeds

YRHYV = yield rate of high yield variety seeds (Kg. Hec)

PAHYV = proportion of area under high yield variety seeds.

It can be assumed that the adoption of HYV seeds has taken place only in irrigated land and the unirrigated lands are cultivated fully with TV seeds. This assumption is justified due to the fact that HYV seeds requires assured water supply for cultivation.

Since, unirrigated lands are cultivated by only TV seeds the equation for base yield rate (eq 2) for unirrigated land will not contain YRHYV and PAHYV terms. But, the base yield rate equation for unirrigated land will contain another important factor YRBFI (yield rate build-

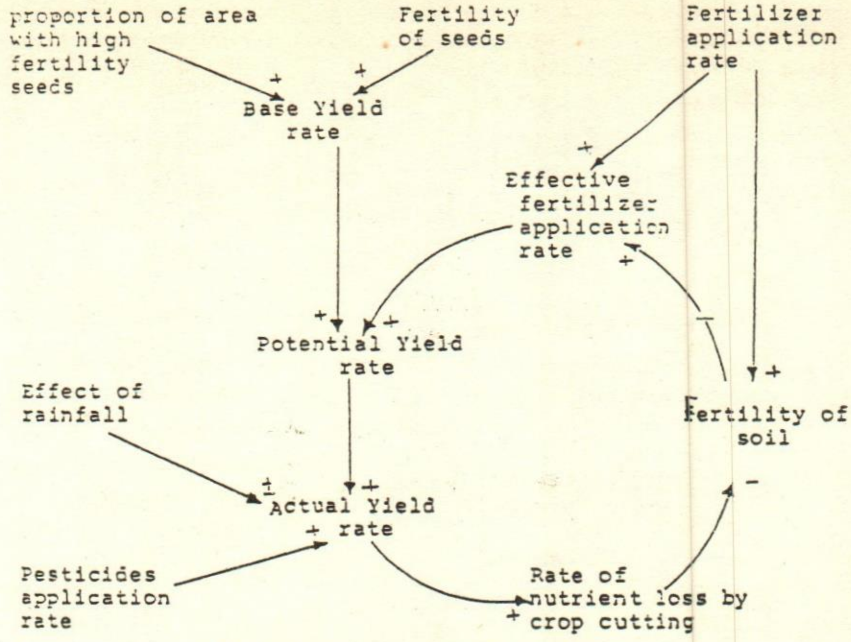


Fig. 6: Mechanism of Building Actual Yield.

ing factor for irrigation). Cooke (1982) has demonstrated how genetic yield rate is built up due to factors such as irrigation, nutrients, pesticides, light and other atmospheric conditions. On the whole, irrigation, i.e. assured water supply, can affect yield by a factor of 2. That is why, yield rate of TV seeds is divided by 2 to arrive at base yield rate in unirrigated land.

Genetic Yield Rate of Seeds

Due to improved genetic properties, yield in HYV seeds is much higher than in TV seeds; sometimes as high as two times. These genetic yield rates are, however, usually referred in terms of laboratory conditions. In controlled laboratory situations, the seeds are provided with full irrigation, with normal fertility of soil, with sufficient sun light, with full control and so on. The yield rates, in laboratory conditions and considering 0.60 kg grain yield from a kg of gross yield, for TV and HYV rice seeds reported by Pawar (1975) are in the ranges of 4200 kg hec and 5000 kg/hec, respectively. For wheat it is considered to be 3200 kg/hec and 4200 kg/hec for TV and HYV seeds. The normal Indian wheat type C360, has a yield of 3200 kg/hec and sonalika, a HYV seed and used widely in India, has yield of about 4200 kg/hec (Open University Press, 1983). However, in practice the seeds yield much less when applied to the fields of farmers and it is assumed, for practical purposes, the yield available from these seeds is half of the fertility rate in laboratory condition. Therefore, the following genetic yield rates are chosen for the purpose of formulation of base yield rates:

For traditional wheat = 3200/2 = 1600 kg/hec

For high yield wheat = 4200/2 = 2100 kg/hec

For traditional rice = 4200/2 = 2100 kg/hec

For high yield rice = 5000/2 = 2500 kg/hec

Adoption of High Yield Variety Seeds

The introduction of HYV seeds affects yield rate significantly. How quickly it is adopted is an important determinant of the success of the green revolution. The progress in the use of HYV seeds, no doubt, depends on many tangible and intangible factors. And accordingly, depending on the prevailing situations there can have many dynamics in the spread of HYV seeds. Some of the possibilities are shown in figure 7. Path 1 assumes a constant rate of increase until the whole area is covered by HYV seeds. In path 2, the rate of increase is more at the beginning and reduces as more and more area is brought under HYV seeds. Path 3 is recognised as a traditional "S" curve of innovation which considers take

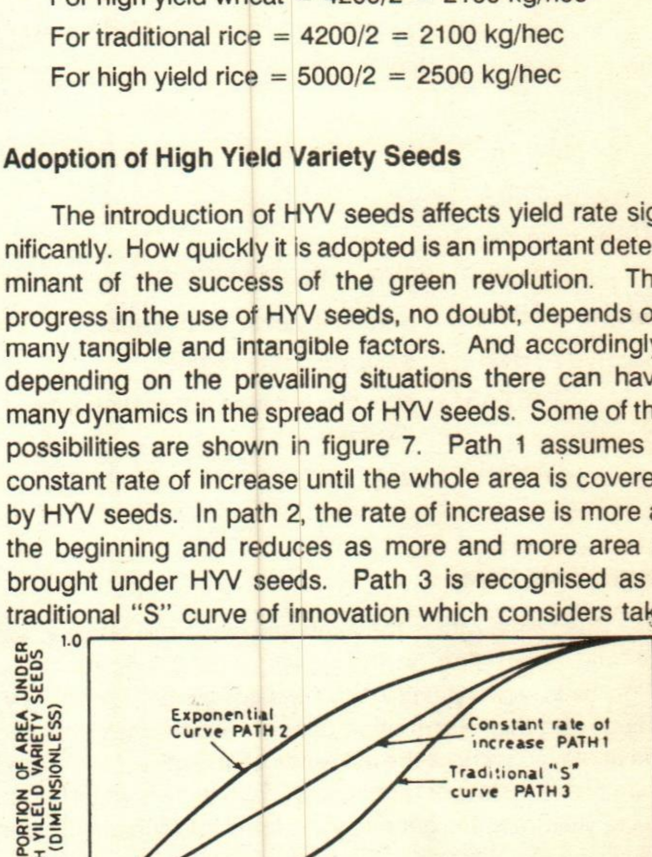


Fig. 7. Rate of adoption of High Yield Variety Seeds

off, rapid growth and saturation phases. However, the Indian condition represents the second situation (Planning Commission, 1981) and the provisions have been made in the model to incorporate this type of behaviour.

For the introduction of high yield rice seeds:

$$PAHYVR = 1\text{-}EXP(-M1*(TIME\text{-}HYVIT)) \quad (3)$$

where,

PAHYVR = proportion of area under high yielding variety rice cultivation.

EXP = exponential term.

HYVIT = the time of introducing HYV seeds (it is 1965 for Indian agriculture).

M1 = the time constant. The reciprocal of the time constant, i.e. 1/M1, is the time by which PAHYVR achieves a value of 0.70 (i.e. 70% of the area comes under high yield variety). M1 = 0.1 for the Indian agriculture.

For the introduction of high yield wheat seeds:

$$PAHYVW = 1\text{-}EXP(-M2*(TIME\text{-}HYVIT)) \quad (4)$$

where, M2 = 0.2

PAHYVW = proportion of area under high yielding variety wheat cultivation.

So, the areas under tradition variety seeds are:

PATVR = 1–PAHYVR

and, PATVW = 1–PAHYVW

Effective Fertiliser in Land

The effective fertiliser application rate which is nothing but the actual amount of nutrients left in the soil after depreciation is determined by the fertiliser application by the farmers and the fertility of the soil. It has been assumed here that the fertility of the soil has a major role to play in determining the actual amount of nutrient available to the plant. If the land becomes inferior in nutrient content at any point of time, some amount of fertiliser applied currently will be used to replenish the deficit. The effective fertiliser equation has a general form:

$$EF = F - SD \quad (5)$$

where,

EF = effective fertiliser (kg/hec).

F = fertiliser application rate by the farmers (kg/hec).

SD = soil depreciation in nutrient content (kg/hec)

The two components of effective fertiliser, i.e., fertiliser application rate and soil depreciation are described now.

Fertiliser Application Rate

Fertiliser is the major input to the fields and varies between irrigated and unirrigated land. Fertiliser distribution is shown in figure 8. Total supply of fertiliser in rice and wheat is distributed between rice and wheat at 60/40 proportion. Again, irrigated land uses three times more fertiliser than unirrigated land.

A further modification of fertiliser use can be made if we consider purchasing of fertiliser by big and small farmers. A big farmer with high purchasing power is likely to buy and apply more fertiliser than a small farmer. This will make a difference in the yield of land.

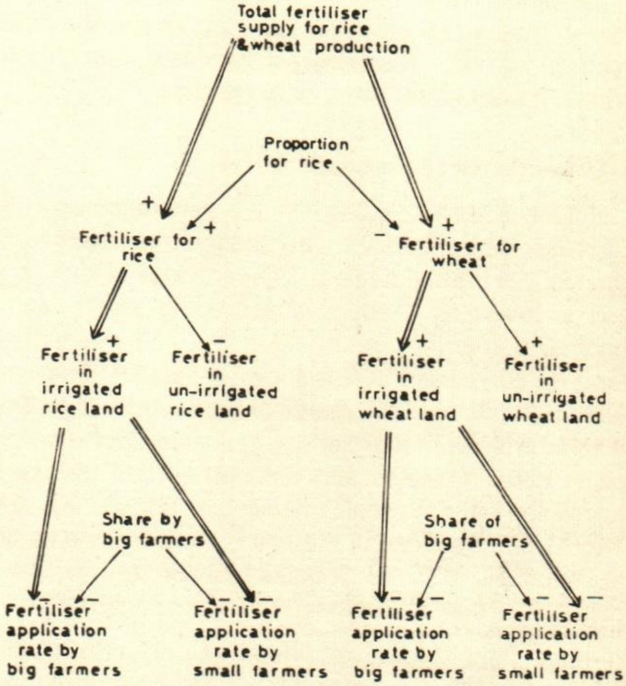


Fig. 8. Distribution of Fertiliser

Fertility of Soil

The actual condition of soil in terms of its nutrient content determines the amount of effective fertiliser. The soil fertility, the opposite of which is called the soil depreciation (SD), is formulated in great detail. Soil depreciation is nothing but the cumulative effect of the amount of fertiliser put into the field, the amount of nutrient taken out of the field by way of crop cutting and nutrient recovery through natural processes. Thus, the general form of soil depreciation (SD) equation is:

$$SD \int_{0}^{t} (NTLCT - F - NR) \quad (6)$$

where,

NTLCT = nutrient taken out of land by crop cutting.

F = fertiliser application rate.

NR = nutrient recovery by the natural process.

There is no actual data available on soil condition. For the purpose of modelling in this exercise the soil fertility is considered to the normal, i.e., SD = 0, at the base year of the model run. The amount of nutrient lost from land due to crop cutting varies according to the type of crop. It is assumed 1kg of nutrient is taken out of land for every 26 kg of rice yield and for every 24 kg of wheat yield (Cooke 1982). Natural recovery of nutrient in the soil by ion exchange and biological process is also important in determining the fertility of soil. It is assumed almost all the deficit in nutrient in the soil will be recovered through the natural processes so long as the shortfall is about 20 kg/hec. The recovery increases with shortfall giving a maximum recovery of 25 kg/hec.

Yield Response to Fertiliser

Effective fertiliser along with the yield response curve of fertiliser determines the contribution of fertiliser to the potential yield rate equation. The response of fertiliser to yield is expected to behave according to the law of decreasing marginal return to scale and the form of response curve used here is shown in figure 9. Desai and Patel (1983) derived the marginal productivity of fertiliser for various levels of fertiliser use in rice and wheat cultivation in different States and established that the law of diminishing return to scale prevailed in India during 1976-77 to 81-82. Because of the use of time series data and the limitations of Cobb-Douglas function, however, they could not be sure about the absolute response figure.

Most of the studies, reported by Cooke (1982), Desai and Patel (1983), Grewal and Rangi (1983), present yield response data from pilot experiments and at very low level of fertiliser use. In Indian situation at present, the average fertiliser consumption is about 25 kg/hec and corresponding marginal yield response is about 9 (Grewal and Rangi, 1983). At a fertiliser application rate of 225 kg/hec, the marginal contribution drops slightly and works out to be 8 (Cooke, 1982). In figure 9, the same trend of marginal yield response, i.e., 0.5 less for every 100 kg increase of fertiliser application, is assumed.

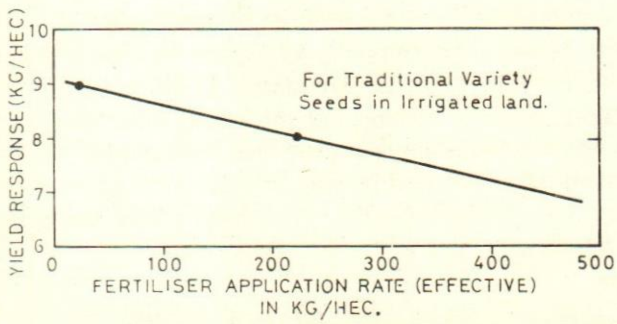


Fig. 9. Yield Response to Fertilizer

The marginal yield response presented in figure 9 corresponds to the traditional variety seeds. The contribution to yield from HYV seeds is considered to be 1.5 times higher of traditional variety seeds. Furthermore, in unirrigated land the yield response is expected to be at least 10 per cent less than that in irrigated land. With the derivation of potential yield rate it is now possible to write the equation for the actual yield.

$$\text{YIELD} = \text{PYR} * (1 - \text{YLP}) * (1 - \text{ERF}) \qquad (7)$$

where,

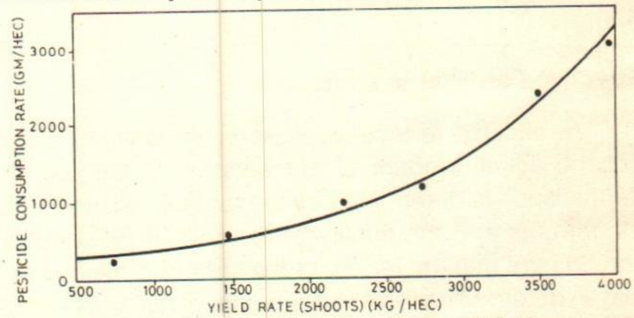
PYR = potential yield rate

YLP = yield loss due to pests

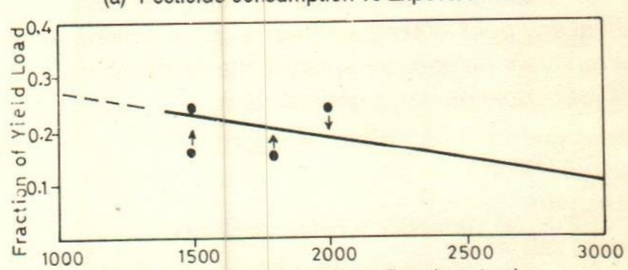
ERF = effect of rainfall.

Yield loss due to Pests

Yield loss due to pest attacks is very important an the pest management requires investigation from system point of view (Teng & Savary, 1992). According to the Sixth Five Year Plan (Planning Commission, 1981) 19. per cent of the total cropped area suffered from pes attacks in 1976-77 and about 24 per cent of rice crop are were affected. The consumption of pesticides is assumed to follow actual yield adjusted for a smooth trend with ar



(a) Pesticide consumption vs Expected Yield



(b) Yield Loss vs. Pesticide Consumption

Fig. 10. Effect of Pesticide on Actual Yield.

djustment period of three years. Figures 10(a) and 10(b) how the relation between smoothed yield rate and pesticide consumption. This shape of the curve is derived om the cross-country data for yield and pesticide conumption for India, Japan, USA and Korea as reported by Shroff and Kaimal (1980). Once the pesticide consumption rate is determined it is possible to calculate the loss of yield. The loss of yield decreases as pesticide consumption increases and it is evident from Figure 10(b). The data points on the figure are adopted from results of pilot studies carried out by Ghodake and Jha (1981, p-38).

Effect of Rainfall

Rainfall plays an important role in crop production. The extent of damage that can be inflicted upon the economy by adverse weather became clear during the drought period of 1965-67 and again in 1979. The food production fell below 20 per cent of normal production and the economy was hit severely.

Rainfall affects food production in two ways: it affects the area of cultivation and the actual yield rate. The effect of rainfall, in terms of fraction of food production lost, is calculated from actual rainfall index (Bhatia, 1983) and actual food production statistics (Directorate of Economics and Statistics, 1978; 1980). Rainfall indexes (RFINDX), calculated from actual data, measure the actual amount of rainfall in percentage of the normal amount. If the index number for a year goes above 100 it means there has been excess rainfall and in that situation crop production has suffered due to flooding. On the other hand, the index showing a value of less than 100 represents a drought situation. Effect of scarce rainfall might be more severe on rice than on wheat. While yield rates of irrigated rice and wheat land are affected considerably by rainfall shortages, the effect on unirrigated land is not so severe. Unirrigated wheat land cultivation can survive rainfall shortage of higher magnitude than unirrigated rice land.

The Model Behaviour

The equations for the model are written in the format as required for simulation with the DYSMAP package (Cavana and Coyle, 1982). The actual equations for the model and the description of the equations are given in Mandal (1986). The model is simulated in CYBER 180/840 main frame computer.

Model Validation

Prior to the use of this model for policy tests, it has been tested extensively for validity. A scheme similar to that suggested by Sterman (1984) has been followed. The model has been tested for structural adequacy, parameter verification, dimensional consistency and historic behaviour reproduction.

Assigning initial values for level variables parameterization of constants and table functions received great attention in equation formulation. The choice of appropriate initial value for level variables and value for constants and table functions is directly related to the model description and is dependent on the published data from various sources. However, from time to time, difficulties have been faced regarding the reliability as well as the availability of appropriate data. In such situations, personal judgements have been applied. The available data have been modified suitably or in case of nonexistent data, appropriate assumptions have been made. But, these subjective judgements have been substantiated by quantifying their effects on the overall behaviour of the model with the help of Dysmod package (Coyle, 1982).

Dysmod is an optimisation package which optimises an objective function (either maximisation or minimisation) subject to a given range of values for constants and table variables. These constants and table variables are assumed to have direct bearing on the objective function. It is possible to formulate an objective function which calculates the difference between the observed and simulated values of a variable or a set of variables and minimises the difference over time through the running of Dysmod program. Dysmod finds the optimum value of the objective function and the best values of the constants and table variables. These best values are the most appropriate values for the parameters which produce the desired optimum behaviour of the model. So, by using Dysmod it is possible to estimate and justify the appropriate value of the parameters to produce the expected behaviour of the system. Optimisation programs have been run for the variables related to land development, production of rice and wheat, and formulation of yield equations for rice and wheat.

The optimisation procedure was particularly helpful to quantify the abstract variables such as the level of soil depreciation (SD). There is no data available quantifying the amount of the nutrient in land at any particular year. To find a reasonable initial value for eight soil depreciation equations (eq. 6), it was decided to minimise the deviation of yield rates from actual values subject to a wide range of initial values for soil depreciation. The range varied from – 30 kg/hec to 0 kg/hec for all types of land. The simulation, however, produced 0 kg/hec as the best value of soil depreciation for all types of land.

The reproduction of historical behaviour is the single most important test in ascertaining confidence with the food production model. The model simulated the behaviour of land, yield and food production for the period 1965 to 1980. The model generated behaviour and the actual past behaviour are shown in Figures 11(a), (b), (c) and (d). As can be seen, the simulated and actual values are close in terms of trend and magnitude.

Scenario Generation

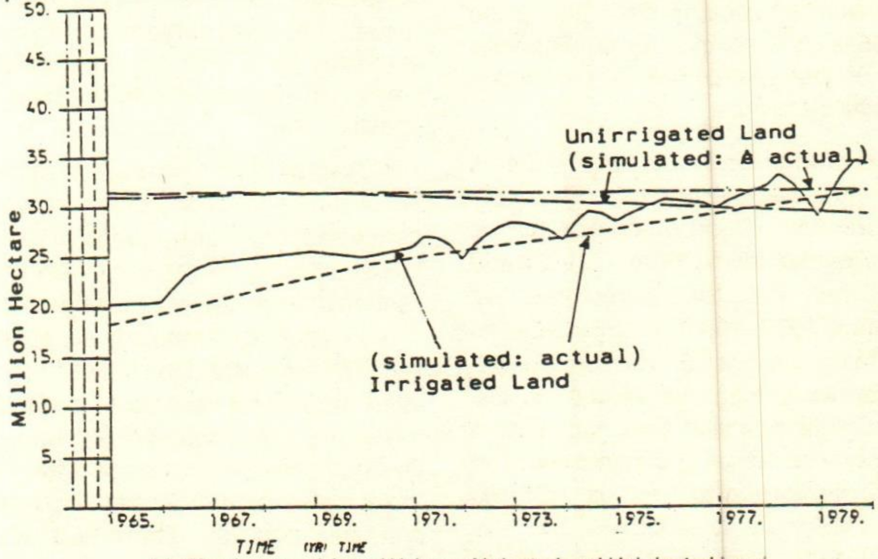
The model has been used to generate five alternative scenarios for food production and they are discussed here. The policies tested to generate the scenarios are:

Policy 1: What will happen to food production if the present practices are continued in the future?

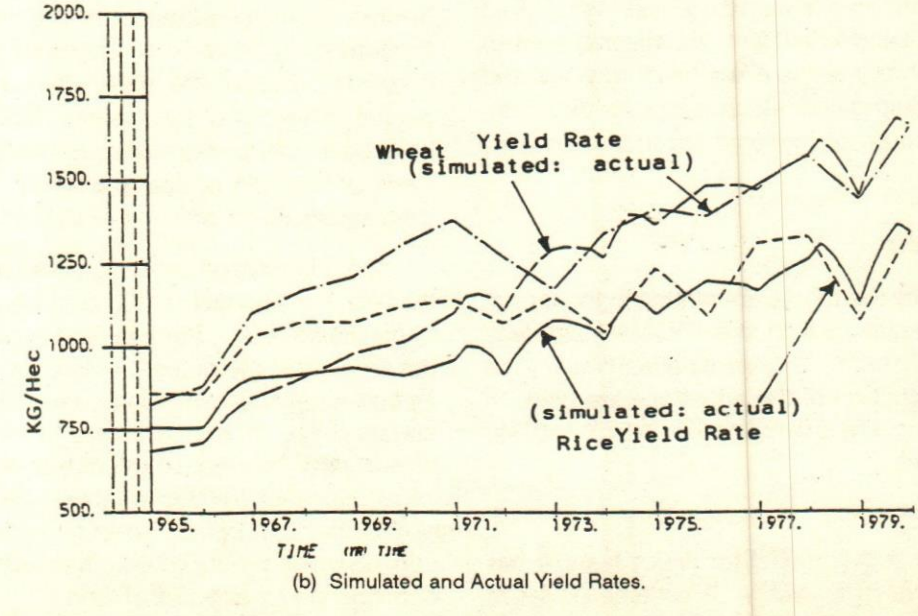
Policy 2: What will happen to food production if · agricultural investment is allocated to irrig tion schemes? As per the current practi about 60 per cent of the total agricultur investment is allocated to irrigation, 20 p cent in land creation, 10 per cent in cash cro production and 10 per cent in livestoc production.

Policy 3: What will happen to food production if a agricultural investment is allocated to lar creation?

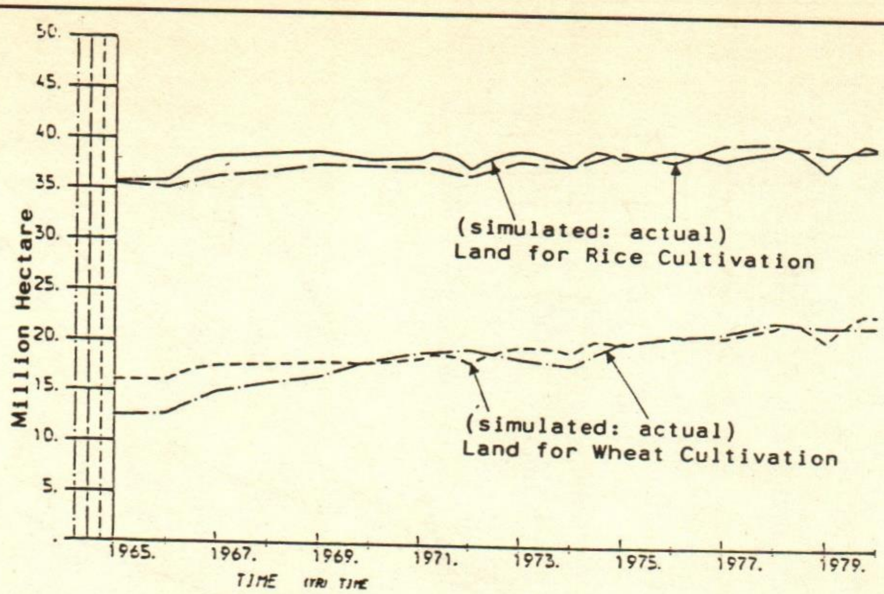
Policy 4: What will happen to food production agricultural investment is allocated at the rat of 70 per cent to irrigation and 30 per cent t land creation?



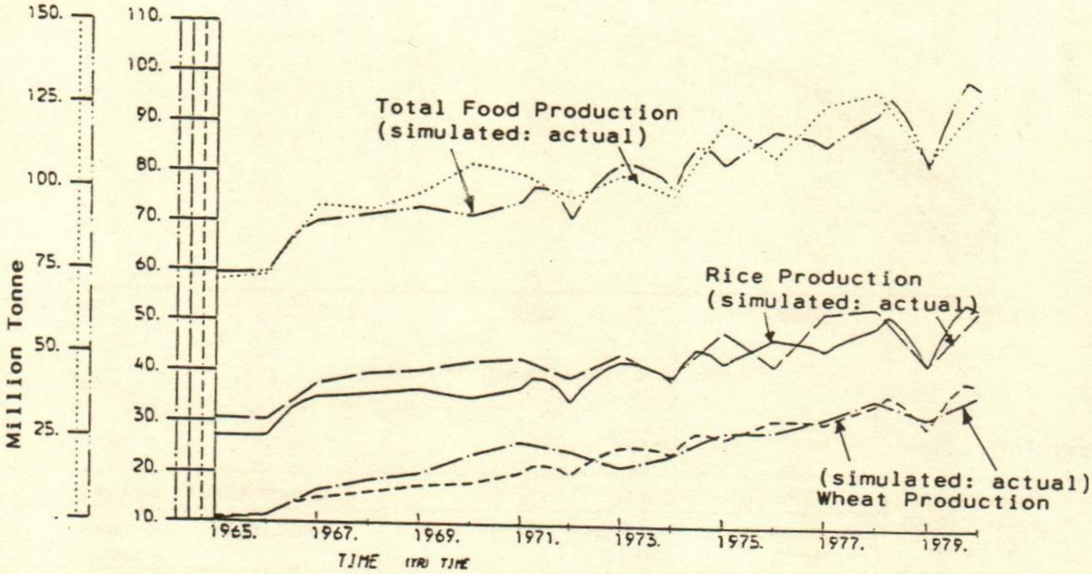
(a) Simulated and Actual Values of Irrigated and Unirrigated Land



(b) Simulated and Actual Yield Rates.



(c) Simulated and Actual Values for Rice and Wheat Land.



(d) Simulated and Actual values of Rice, Wheat and total food production.

Fig. 11.

ˈolicy 5: What will happen to food production if cultivation becomes more intensive, a new generation high yield variety seeds introduced and the past behaviour of rainfall repeated?

The results of the policy experiments are summarised ˈ major variables in table 1. The dynamics of food ˈoduction under these policies are shown in Fig. 12. The ˈst scenario is represented by the continuation of the ˈst behaviour (Policy 1) and it shows a satisfactory food ˈuation until 2007. The food production falls short of ˈquirement at this time and the buffer stock of food starts to decrease. This result is due to the fact that the rate of land creation under this policy is very low and eventually there is no more land to irrigate. The model clearly indicates the effects of the longer term constraints associated with land development and highlights the need for caution in determining the balance of investment among various activities of agriculture system.

The second scenario, generated by Policy 2 shows a gloomy picture. The rate of irrigation and, hence, food production resulting from this policy is very unstable. When there is no land creation taking place and the investment in irrigation is very high (as in this case), the avail-

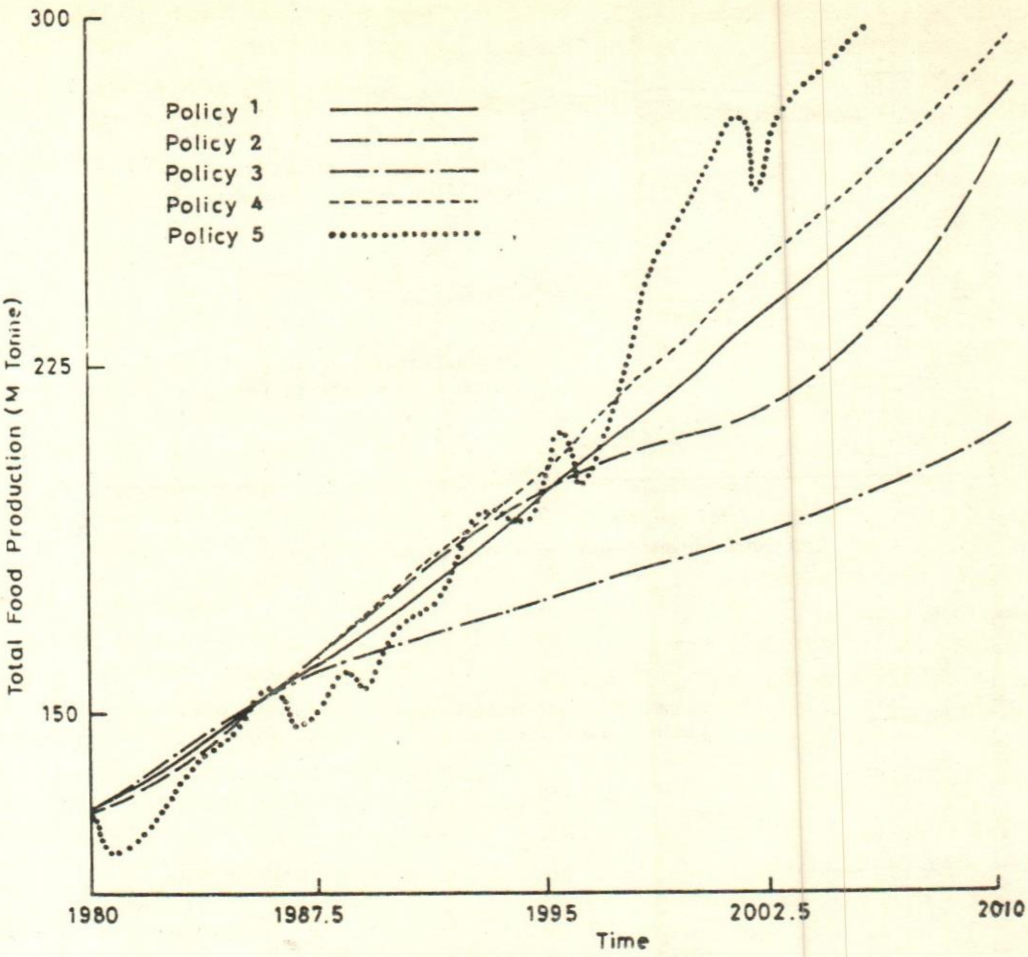


Fig. 12. Food Production with various Policies

Table 1: Summary of Policy Tests.

	Food Production at 2010 AD M. Tonne	Cumulative 1980-2010		Growth Rates (% per year)			
		Food Import (M.T.)	Food Export (M.T.)	Food Production	Irrigated Land	Unirrigated Land	Investment Rate
Scenario 1	285	0	68	2.57	3.31	– 2.51	6.95
Scenario 2	273	163	80	2.43	2.56 (4.70 from 1980-95 and 0.4 from 1995-2010)	–7.57 (–9.93 from 1980-95)	5.63 (6.93 from 1980-95 and 4.34 from 1995-2010)
Scenario 3	218	361	44	1.67	– 1.85	2.80 (4.89 from 1985-95 and 0.75 from1995-2010)	4.84 (7.18 from 1980-97 and 1.84 from 1997-2010)
Scenario 4	295	0	166	2.70	3.45	–2.10	6.52
Scenario 5	382	—	—	3.58	4.80	– 1.05	7.29

able land is irrigated rapidly. When the available land runs out, irrigation falls to zero and remains so until such a period when sufficient unirrigated land is accumulated by way of depreciation of irrigated land. The overall percentage growth rates in available land resources and foo production, as evident in table 1, are significantly wors than those resulting from the first scenario. Food imports during the later periods of the simulation have been quit substantial. The third scenario, generated by Policy 3, as might be expected, shows an even worse situation, as confirmed by the figures presented in table. 1. The total wasteland is converted into unirrigated land within 15 years and there is no further development in land later on. Although the amount of unirrigated land increases, the total food production remains at an alarmingly low level. The fourth scenario, corresponding to Policy 4, presents a satisfactory performance with respect to food. The food situation in this policy is better compared to previous three scenarios. There is no import of food and the export has been of the order of 166 million tonnes throughout the period. The fifth scenario (Policy 5) corresponds to a major alternative way to increase food production other than increasing land. The purpose is to increase yield by more intensive land use combined with the use of two phase of new generation high yielding variety seeds and analyse their impact on food scenario. This situation reveals the best performance of food production. Food production increases at a rate of 3.58 per cent per year. The sudden fluctuations in food production in this scenario is due to repetition of the past behaviour of rainfall in the formulation of this policy.

Conclusions

The modelling of yield and food production as presented in this paper deviates from the traditional approach to food estimation and focuses on generating long-term trend. The concepts of systems used in this modelling bring a number of variables under the modelling framework. The inputs such as types of seeds, fertiliser, rainfall, pesticide use etc. have been incorporated easily. The potential of this model in agricultural policy making is very high. Indian agriculture is capable of meeting its domestic food requirements and produce surplus for exports. But, behind the success, there lies the real challenge of choosing the right policy(ies). For example, food situation will be comfortable only with Policies 4 and 5, i.e. either investing at 70 per cent for irrigation and 30 per cent for land creation or by introducing new generation high yield variety seeds and intensive cultivation. With modifications, the model can be used for analysing issues important to food reserve, rural income distribution, inter-sectoral investment, etc. With an enlarged model (in scope and length) the author has demonstrated the usefulness of this type of model in analysing socio-economic policies (Wolstenholme and Mandal, 1989). The model presented in this paper can also be used to represent a dynamic model for food production in other developing countries.

References

Acharya, S. (1992), Rates of Return in Indian Agriculture, Economic and Political Weekly, Vol. XXVII, No. 3

Bhatia, M.S. (1983), Crop-weather Relationship for Pre-harvest Forecasting of Production of Crops, Indian Journal of Agricultural Statistics, July.

Cavana, R.Y. & R.G. Coyle (1982), Dysmap User's Manual, University of Bradford.

Cooke, G.W. (1982), Fertilizing for Maximum Yield, (3rd ed.), Granada Publishing Ltd, London.

Cogıe, D.K. (ed) (1982) Dysmod user's Mannual, University of Bradford

Desai, D.K. & N.T. Patel (1983), Improving growth of Foodgrains Productivity in the Western Region of India, Indian Journal of Agricultural Economics, Vol. 38, No. 4.

Dev, S.M. (1991), Constraints on Agricultural Productivity: A District Level Analysis, Economic and Political Weekly, Vol. XXVI, No. 39

Directorate of Economics and Statistics (1978), Indian Agriculture in Brief, 17th ed., Ministry of Agriculture, Government of India.

Directorate of Economics and Statistics (1980), Indian Agriculture in Brief, 19th ed., Ministry of Agriculture, Government of India.

Ghodake, R.D. & D Jha (1981), Pesticide Use Decision in Agriculture, Indian Journal of Agricultural Economics, Vol. 36, No. 2.

Grewal, S.S. P.S. Rangi (1983), An Analytical Study of Growth of Punjab Agriculture, Indian Journal of Agricultural Economics, Vol. 38, No. 4.

Horie, T.M. Yajima & H. Nakagawa (1992), Yield Forecasting, Vol. 40, Nos. 1-3

Mandal, P. (1986), Modelling and Analysis of National Development Strategies for India, PhD Thesis, University of Bradford.

Open University Press (1983), The Green Revolution in India, Milton Keynes.

Pawar, M.S. (1975), New Visita in Cereal Production, in Financing Agriculture-Annual 1975, Agricultural Finance Corporation Ltd, India.

Planning Commission (1981), Sixth Five Year Plan 1980-85

Shroff, K.G. & S.S. Kaimal (1980), Pesticides: Boon or Bane? Commerce, Bombay, June 21.

Sterman, J.D. (1984), Appropriate Summary Statistics for Evaluating the Historical Fit of System Dynamics Models, Dynamica, Vol. 11, part II.

Teng, P.S. & Savary (1992), Implementing the Systems Approach in Pest Management, Agricultural Systems, Vol. 40, Nos. 1-3

Wolstenholme, E.F. & P. Mandal (1989), Analysis of Socio-Economic Policy Alternatives for a Developing Country, System Dynamics: An International Journal of Policy Modelling, Vol. 2, No. 1 ☐

Productivity of Capital Investment on Marine Fishing Crafts of Kerala

P.G. Luke

Past studies have established that the marine fisheries sector of Kerala is in a state of crisis due to over exploitation of resources, over capitalisation in modern crafts and poor returns in the wake of uncontrolled motorisation of artisanal crafts. This study is addressed to the issue of how the productivity of capital or labour in a fishing unit varies with the higher size classes of investment cost. Adopting a new method of computation, the present study estimates the size productivity of capital and labour for six size classes of investment in 1981 and 1988 representing the pre and post motorisation stages. The observation is that size productivity has fallen significantly during the past decade and it is inversely related to the size of investment. The analysis provides the implications of the declining size productivity and recommends positive role by credit institutions.

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The marine fisheries sector of Kerala is in a state of crisis in recent years consequent to certain developments of the past two decades. The annual marine fish landings in Kerala coast over past twenty years have shown stagnation and wide fluctuations. The artisanal fishery was well developed till mid 1970s and the maximum yield of that decade was recorded at 448269 tonnes in 1973. The maximum sustainable yield in the inshore waters (0-50 metres depth) is estimated at 377000 tonnes (PCO and SIFFS, 1991). The main thrust for fisheries development until 1980 was on augmentation of fish production particularly prawns for increasing foreign exchange earnings. There was an uncontrolled expansion of trawlers and purse seine boats which caused much damage to artisanal fishermen and the inshore resources. By 1980 there were 30000 artisanal non-motorised crafts and 3000 mechanised boats exploiting marine resources covering about 30 Ha each. The annual production declined gradually to 279543 tonnes in 1980.

Sharp reduction in the share of production of artisanal sector from 86.6 per cent in 1970 to 51.8 per cent in 1980, caused considerable misery in the traditional sector with 6 lakh population of which 1.15 lakh were active fishermen. They reacted strongly in the early 1980s by resorting to motorisation of their crafts for competing more effectively and to reach distant waters in search of new fish resources. By 1990 about 10000 artisanal crafts were motorised and this process is continuing even today. But the marine fish landings in this stage oscillated around 3.5 lakh tonnes until 1988. Table 1 shows the fluctuations in annual marine fish landings during the period 1969 - 1991. It can be seen that the share of artisanal sector (non motorised and motorised) decreased steadily over past two decades. The shares of annual production in 1988 under non-motorised, motorised and mechanised categories were 7 percent, 51 percent and 42 percent respectively.

Table 1: Fluctuations in marine fish landings of Kerala

Period	Annual Production (Lakh Tonnes)		Shares of artisanal sector (percentage)	
	Low	High	Low	High
1969-75	2.948	4.483	57.2	90.4
1976-80	2.795	3.733	51.8	82.3
1981-87	2.740	3.929	50.2	74.6
1988-89	4.688	6.475	58.0	67.9
1990-91	5.642	6.629	NA	NA

Source: PCO and SIFFS, 1991.

The over fishing on the heavily exploited resources has resulted in depletion of oceanic production. Balakrishnan Nair (1989) recorded "......... unless this unbridled growth in the effort-pressure is controlled, there is every chance of the depletion of the valuable resource, once the fishery independent factors also join hands with fishery dependent factors". The problem of reducing catch by small fishermen is aggravated by the low price of output, a consequence of lack of storage facilities and marketing infrastructure. The economic disparities between different strata of artisanal fisherman have increased widely. The owners of bigger crafts reap large profits while smaller fishermen are marginalised. The unequal access to the common resources of the sea has been threatening the very survival of smaller crafts operated by the majority of the fishermen. As SIFFS (1991) census has shown, there are about 1144 very large crafts, 2820 large crafts, 6220 medium crafts, 5185 small crafts and 15090 Kattamarams with total of 30459 artisanal crafts in Kerala (table 2).

Table 2: Size-wise distribution of artisanal crafts (1991 data)

Category	Very Large	Large	Medium	Small	Total
I. Motorised					
Plank canoes	1144	510	334	1296	3284
Dugout	—	2100	2429	223	4752
Plywood	—	63	1815	—	1878
II. Non-Motorised					
Plank canoes	—	138	666	917	1721
Dugout	—	9	976	2749	3734
Kattamaram	—	—	12682	2408	15090
Total	1144	2820	18902	7593	30459

Note: Small includes transom and others of 1991 census
Source: SIFFS, 1991

The investment cost in the artisanal fishery has increased on the average ten times over last decade. As per the systematic study of PCO and SIFFS (1991), the capital investment during 1988 in small motorised boats was in the range of Rs. 23000 - 56000 and that of ringseine unit was Rs. 104000 - 384000 while the non-motorised boats were costing only Rs. 3000 - 13000. In the last four years, the cost of large units has been increasing at about 20 percent per annum. The hike in investment cost is due to the substantial increase in the size of craft, gear and engine as well as the price rise of manufactured components using international technology. Another significant problem is the growth in the cost of operation with higher non-renewable energy consumption. As the output of fishing trip is more uncertain, the capital intensive fishing unit is an increasingly risky proposition. To quote from the PCO and SIFFS (1991) study,

> " ... It is evident that investment in craft, gear and engine have varying impact on the productivity, income and profitability of the motorised fishing units. However, the relationships are hardly of the same sort or scale and only greater observations over time can help to establish the degree of correlation between the nature and pattern of investment in a fishing unit and its productivity/ profitability".

The unequal access to the common resources of the sea has been threatening the very survival of smaller crafts operated by the majority of the fishermen.

A focus on the credit markets in the marine fishing sector is pertinent here. Plattean, Jose Murickan and Delbar (1985) opined that the process of motorisation/mechanisation was superimposed by outside agencies and was not the outcome of the growth of productive forces from within the traditional economy. With the liberal financial assistance of formal and informal credit agencies, there is the growth of a new class of owners of modern crafts with other non-fishing occupation also. The role of credit institutions in the over capitalisation process resulting in widening of inequalities of asset and income distribution has to be seen in proper perspective. According to the 1989 estimate, the number of out board motors issued under various subsidy schemes was 3605. Around 25 percent of credit in marine fisheries sector has been extended by credit institutions.

Past Studies and Present Analysis

The factors responsible for the above mentioned issues can be classified as economic, technological, ecological, institutional and political. The present analysis is confined to the economic factors with special emphasis on the productivity of the two primary factors of production namely capital and labour. In this context an analogy with agriculture may be made. The method of size productivity analysis has been used frequently in respect of agricultural crops in order to study whether the per acre productivity of a factor changes with farm size. Similarly the issue addressed here is how the productivity of capital or labour in a fishing unit varies with the higher size classes of investment cost. The measures of size productivity would be of immense help in evaluating how far remunerative or economical it is to invest in a particular size of fishing unit. It also helps to determine the income differences between two size groups of fishermen. However, the size-productivity relationship has not been studied in the case of marine fisheries sector of Kerala. The salient features of the treatment of productivity as available in the past studies regarding the sector are as follows.

One of the outstanding characteristics of the artisanal sector – pre motorisation phase – was its flexibility in respect of craft and gear combinations depending on the operational conditions. As many as 30000 artisanal crafts of different sizes operated in about 220 recognised landing places with 20 types of gears. In addition there were about 3300 mechanised boats using trawler nets, gillenetters and purse seiners. The variety of craft and gear combinations for the individual fisherman as well as for the villages and seasons, rendered a study of the costs and earnings of artisanal fishing very complex and difficult. Even a reliable census data of the size and characteristics of the population of crafts was not available.

In this situation the pioneering study "Economics of artisanal and mechanised marine fisheries in Kerala" conducted in 1981 is an invaluable reference (John Kurien & Willman R, 1981). The study covered a representative sample of 242 fishing units, 22 craft-gear combinations, 21128 fishing trips during 1980-81, and 15 centres along the coast of Kerala. The analysis of data provided the average capital productivity (ACP) average labour productivity (ALP) and capital intensity of 22 types of fishing units. But the ACP and ALP comprised the joint effects of capital invested and labour of the crew. The factor productivity was not calculated keeping the other factor constant. This has rendered the analysis in the 1981 study on the efficiency of different types of units inconclusive and misleading.

Later in the wake of large scale motorisation of artisanal crafts, a detailed techno-economic analysis of motorisation was undertaken in 1988 jointly by the Programme for Community Organisation and South Indian Federation of Fishermen Societies. Trivandrum (PCO and SIFFS, 1991). The main characteristics of the motorisation phase (1981-1988) was greater uniformity of gear type, enhanced investment and operating costs and greater dependence on internationally controlled technology. The very small crafts like Kattamarams remained non-motorised. It was observed for the 1988 study that the motorised units can be classified according to the types of crafts which generally reflected the classes of investment cost. The plywood boats are a new modern addition to the list. The survey was carried out in 13 centres covering entire Kerala State and Kanyakumari District of Tamil Nadu covering 143 fishing units and 22500 fishing trips during 1988. There were 101 motorised and 42 non-motorised artisanal units in the sample. The emphasis of the study was on the operational analysis. As a measure of average capital productivity, the value of annual output per craft is available in the report. Similarly, the value of annual output per fisherman is given as the measure of average labour productivity. Obviously, there is no systematic analysis of the productivity of capital and labour in the 1988 study.

The past two studies for 1981 and 1988 are not strictly comparable due to changes in the size of craft, gear designs, scale of operation, work organisation, and other factors relating to motorisation. As the classifications of fishing units are different in these studies, the productivity indices if compiled using the craft types given in the reports, are not comparable. The investment cost is amenable for comparison between two time periods, subject to the correction of inflation. It also accounts for the allocation of productive capital factors into different activities of the economy. Hence, size productivity of a factor with reference to investment cost is the only index which can pass the test of time, for meaningful comparison between the pre-and post-motorisation stages. This study, therefore, has identified six size classes of fishing units on the basis of the pattern of investment costs prevailed in 1981 and 1988 as given in the respective past studies. Then the size productivity measures are compiled for these six size classes using the published data of the 1981 and 1988 studies under reference.

Methodology

The fluctuations in the production of marine fisheries sector depend on two groups of factors:

- External factors which are fishery independent factors such as temperature, rainfall, salinity and currents. These factors are beyond human control and the variations in these factors normally do not undergo violent changes for a considerable time.

- International factors which are fishery dependent factors such as nature, size and shape of gear used, number of fishing crafts, number and skill of fishermen and fishing time. The changes in pattern of landings, size variations and species composition can be, to a large extent, attributed to these factors which can be controlled with will and wisdom.

The effects of these external and internal factors are inherent in the productivity estimates. However, we consider here only the productivity of capital and labour in relation to the size of investment, assuming that other factors affect the different fishing units uniform.

The investment on a fishing unit mainly consists of the costs on craft, gear and out board motor which are obviously of different physical units. In order to circumvent the addition problem, the value of total investment is taken as the capital. Along with the technological advancements, the skill of fishermen also has improved. The variations of the quality of human labour associated with different crafts are not taken into account here and man-hour is adopted as the standardized unit of labour.

Capital and labour are to a great extent complementary factors of production in marine fisheries sector. Hence, the productivity of one factor has to be estimated keeping the other factor constant. With this objective, the size productivity indices of capital and labour as well as size capital intensity are calculated in the present study in a new method as detailed.

The size class of investment cost of a fishing unit is measured here using the scale of Rs. 10000 which is an arbitrary unit similar to an acre for agriculture. Then the size factor of a fishing unit is defined as the total investment cost divided by 10000. The size capital productivity (SCP) of the craft/fishing unit is the increase in the value of output by a unit increase in the size factor, keeping the other input (labour) constant. The formal definition of SCP is given as the value of output per manhour of labour divided by the size factor. For estimating the SCP, the total production of a typical craft for the entire year is taken into account. This smoothens out the effects of different craft-gear combinations used by the fisherman for different seasons in view of the relevant external and internal factors.

Capital and labour are complementary factors of production in marine fisheries sector.

As the process of catching fish forms only a portion of the total human labour during the trip, one can in practice calculate two different parameters – the catch per man hour of fishing and the catch per man-hour at sea. The latter parameter is adopted here. The catch per man hour of effort (CPUE) is a standardized measure of average labour productivity which helps to make comparisons across different crafts/fishing units. We have to remove the effect of amount of capital investment in order to get the measure of labour productivity. The size labour productivity (SLP) is formally defined here as the CPUE per unit of Rs. 10000 investment cost.

In fisheries sector where labour is abundant and cheap and capital goods are relatively scare, the measure of capital intensity indicates the use of capital in relation to labour.

In fisheries sector where labour is abundant and cheap and capital goods are relatively scarce, the measure of capital intensity indicates the use of capital in relation to labour. An increase of capital intensity when craft size increases implies that more capital is substituted for labour. The effect of this development on the levels of personal income and employment in the sector is obvious. The size capital intensity (SCI) of a craft unit is defined as the ratio of the size factor to average crew size per trip.

The operational data of a fishing unit is collected for the whole year, through one trip. Gross profit of a craft is defined as total revenue for the year minus operating costs (fuel, food expenses, sales commission, crew share etc.). The total revenue depends on the quantity of fish sold and the daily prices of fish determined by the demand and supply conditions of the market. It is interesting to compare the main operational data for 1981 and 1988 of the six size classes of fishing units for observing the pattern of growth in the sector (table 3).

Table 3: Operational Data of Six Size Classes of Fishing Units for 1981 and 1988

Size Class of Investment	Type of fishing unit	Average Investment Cost (Rs.)	Average Crew Size	Production (Kg)	Revenue (Gross Profit) (Rs.)
1981 Non-motorised crafts and Mechanised Boats					
I	A	1689	2	1168	3158 (680)
II	B	4473	6	2179	5027 (842)
III	C	7667	8	5465	11953 (2520)
IV	Boat Seine	15160	16	18109	24012 (4794)
V	Ring Seine	21397	15	23785	44491 (12586)
VI	Mechanised Boats	101349	5	25000	68423 (2973)
1988 Motorised crafts and Mechanised Boats					
I	Dugout canoes	34256	3.8	7144	32453 (4615)
II	Small plank canoes	39939	3.8	3945	34290 (5108)
III	Plywood Boat	52302	3.9	11151	66040 (12015)
IV	Boat Seine	133863	16.0	51359	148274 (25516)
V	Ring Seine	273453	28.8	188369	474560 (115200)
VI	Mechanised Boat	760000	5	50000	880000 (360000)

A Castnet (Dugout), gillent (Anchovies), Sardine net (Kattamaram), Prawn net (kattamaram), Lobster net (Dugout), Hook & Line (Kattamaram).

B Specialised gill net (Dugout), Boat Seine (Kattamaram), Shore seine Nylon, Prawn net (Dugout), Hook and Line (Plank canoes)

C Shore seine cotton, Driftnet small mesh (Plank canoes), Driftnet large mesh (Dugout, Kattamaram), Hook & Line (Dugout)

Note: The figures are weighted averages compiled from the published data of 1981 and 1988 studies.

The computation formulae of the two size productivity measures and size capital intensity of a typical craft/fishing unit of a particular size class are as follows.

i. $V = \dfrac{\text{Value of fish sold per year per craft}}{\text{no. of trips} \times \text{trip time} \times \text{average crew size}}$

and capital (C) = size factor × 10000

= F × 10000

Then, SCP = V/F = (V/C) × 10000

ii. Average labour productivity (kg/manhour) = CPUE

where,

$CPUE = \dfrac{\text{Quantity of catch in a year}}{\text{No. of trip} \times \text{trip time} \times \text{average crew size}}$

Then, SLP = CPUE/F = (CPUE/C) × 10000

iii. $SCI = \dfrac{\text{Size factor of investment cost}}{\text{average crew size per ship}}$

The index for a size class of investment is the weighted average of the measures pertaining to the typical fishing units of the respective centres in the sample. The indices of size capital productivity, size labour productivity and size capital intensity compiled for 1981 and 1988 according to six size classes of investment are shown in table 4.

Table 4: Indices of Size Productivity Analysis - 1981 and 1988

Size class of Investment	Size Capital Productivity		Size Labour Productivity		Size Capital Intensity	
	1981	1988	1981	1988	1981	1988
I	15.49	4.10	6.50	0.84	0.09	0.95
II	6.47	1.99	2.82	0.25	0.09	1.04
III	3.68	1.85	1.76	1.16	0.18	1.36
IV	1.12	0.56	0.86	0.19	0.09	0.84
V	2.52	0.72	1.35	0.24	0.14	0.90
VI	0.85	0.96	0.32	0.05	2.12	15.20

Note: The indices are computed using the data published in respective 1981 and 1988 studies.

Size Productivity Analysis - Results

The following are certain important observations made from the indices of size productivity analysis given in table 4.

- There is a significant inverse relationship between SCP and size of investment in the marine fisheries sector. The fall in productivity when capital increases was more or less at the same rate in the case of non-motorised (1981) and motorised crafts (1988).
- The SCP has reduced by 1988 to about one third of the level of 1981 across all artisanal crafts. That is, capital productivity has considerably decreased after motorisation.
- The size labour productivity has an inverse relationship with size of investment in the pre-motorisation stage. However with motorisation, in 1988, the SLP varies in a narrow range across the size classes I to V.
- There is a sharp fall in the labour productivity between 1981 and 1988, for all classes of fishing units. So, contrary to the popular belief, motorisa-

tion and mechanisation have led to reduction in labour productivity.

- In the pre-motorisation stage, size capital intensity did not increase considerably with investment in the artisanal crafts. The situation has not changed in 1988 even after motorisation at huge investment. However, the SCI increased by about 7 to 10 times over this period for individual size classes.
- The plywood boats of 1988 shows certain advantage in productivity as compared to other motorised boats.
- The ringseines (size-class V) showed poor productivity even after motorisation. The high investment in ringseine units did not provide better yield per unit of investment, as compared to smaller crafts.
- The small and medium sized units had a distinctly better productivity of capital and labour.
- The mechanised boats have different operational parameters and hence are not strictly comparable with artisanal crafts. The labour productivity of mechanised boats was much lower than artisanal crafts during both time periods 1981 and 1988. The size capital productivity also did not justify the higher investment cost of mechanised boats. But these boats recorded about 17 to 23 times size capital intensity as compared to artisanal crafts.
- 1981 was an extremely bad year while 1988 was a good year for marine fisheries of Kerala. So the productivity measures of other years of pre-motorisation phase would be definitely better than the 1981 levels given in this analysis. On the other hand, other years of post motorisation stage might have realised lower productivity levels than the 1988 levels. So comparing the pre and post motorisation phases, we can safely conclude that the fall in productivity after motorisation is more steep than compiled in this study.

Interpretations and Implications

The size productivity analysis of marine fishing crafts has thrown up certain paradoxical features. In the pre-motorisation stage (1981) the bigger sized units like boat seines and ring seines did not enjoy the advantage of size, if we consider the yardstick of productivity measures. This can be explained by the following major characteristics of a fishing unit assuming it as a production firm. The fisherman operates under risk and uncertainty of the highest order. He is not able to exert any positive influence on the natural process of oceanic production. He cannot increase the catch per trip by changing his variable inputs, because he has to incur all the costs once he leaves the shore. There is no real or pecuniary economies of scale in the fishing operation. Moreover, when the craft is lying idle on the shore, the fisherman does not have any alternate use for his labour, craft and implements. In this peculiar nature of marine fishing, the small and medium sized crafts have an economic advantage over large crafts. There is no significant labour capital substitution in motorised artisanal fishing. This is evident from the proportionate increase in the average crew size per trip when investment increases.

The economic rationale of the investment decisions in the sector is that the profit to investor increases rapidly with higher investments. This is a direct inference from the operational data of table 3. Over the economic life of a big fishing unit, its revenue and profit will be more than proportional compared to a small unit. So the motive of escalating capital investment in the artisanal sector is the competitive advantage over smaller boats which enables the investor to catch larger share of the sea resources and reap huge profits. The pay-back period of big units is about 2 years only as compared to 5 years or more for smaller crafts. The larger units have certain advantages such as longer fishing time, more trips in a year due to greater capability to face risks of sea conditions, fishing in more depth and the use of a more spacious craft to store more fish. Comparing the gross profit levels of ringseines in 1981 and 1988, their revenue and profit increased by about ten times over the period. In this situation, bigger units are favoured by formal and informal credit agencies who finance on the basis of internal rate of return of a project. The cheaper credit under liberal terms and conditions is also contributing to spiralling capital investment in the sector. The investment cost has increased by over 50 percent by 1992 as compared to 1988.

Over the economic life of a big fishing unit, its revenue and profit will be more than proportional compared to a small unit. So the motive of escalating capital investment in the artisanal sector is the competitive advantage over smaller boats

Role of Financing Institutions

Though may committees and studies have dealt upon the adverse impact of over exploitation on the fishery resources, the over capitalisation spree is continuing.

This is because of the commercial attitude of the influential people, government and the credit agencies. Serious economic analysis of the parameters of marine fisheries has not been attempted so far, unfortunately. The foregoing analysis of size productivity measures has established that the economic efficiency in the marine fisheries sector was very low before 1981 and it has still declined over the past decade. The economic efficiency is theoretically defined as the least cost use of resources (inputs) so as to maximise consumer satisfaction or utility. The total investment in motorised and mechanised units is estimated to be around Rs. 400 crores. This type of wasteful capital formation in the motorised boats could have been avoided and the fish production targets achieved if proper investment decisions had been taken in the sector at the appropriate time; the sector could have achieved better employment of resources and equity in distribution of income adding to the economic welfare of the society.

Wasteful capital formation in the motorised boats could have been avoided and the fish production targets achieved if proper investment decisions had been taken in the sector at the appropriate time.

The major portion of the credit from financial institutions (banks and government agencies) has financed the purchase of large motorised crafts and mechanised boats which are expected to realise large revenue and profits from the unfair competition in sea waters. The project lending approach of banks and other credit institutions relies heavily on the expected return of investment and collaterals offered by large borrowers. The genuine credit needs of the small fishermen have not received the due attention of financing institutions and as a result, they are in the grip of private money lenders and merchants. The problems of small fishermen due to the non availability of cheaper credit from lending institutions may be seen against the over capitalisation and exploitation of bigger crafts. Growth with equity is still a dream and market power is the goal of the game. The trade-off between economic efficiency and credit worthiness spells a gloomy future to the small scale fishermen.

The inverse relationship between the productivity indices of capital and labour and the size classes of investment renders a new dimension to the complexity of issues in the marine fisheries sector. There is sound economic justification for reducing the investment cost on a fishing unit as well as for the development of small scale artisanal fishermen. The lending norms and procedures of institutional credit agencies need a thorough evaluation. Time is ripe for a change in the project approach of credit institutions keeping in view the economic and social welfare of the sector.

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References

Balakrishnan Nair N (1989) — "Report of the expert committee on marine fishery resources management in Kerala," — submitted to Government of Kerala.

SIFFS (1991) — "A census of the artisanal marine fishing fleet of Kerala (1991)" — South Indian Federation of Fishermen Societies (SIFFS), Trivandrum.

PCO and SIFFS, 1991 — "Techno economic analysis of motorisation of fishing units", undertaken by Programme for Community Organisation and South Indian Federation of Fishermen Societies, Trivandrum during 1988.

Plattean, Jose Murickan & Deibar (1985) — "Technology, credit and Indebtedness in Marine Fishing", Hindustan Publishing Corporation, Delhi.

John Kurian & Willmann R. (1981) — "Economics of artisanal and mechanised fisheries in Kerala", PCO and FAO/UNDP.

Kerala Fisheries, Facts and Figures (1990) — Department of Fisheries, Government of Kerala.

John Kurien, & Achari T.R.T. (1990) "Overfishing along Kerala Coast — Causes and Consequences". Economic and Political Weekly, Vol. XXV, 2011 - 2018. □

Agricultural Productivity & Labour-Use among Rural Women in Nigeria

C.J. Arene & I. Kalu

The study examines the agricultural productivity of rural women farmers in Nigeria, with particular emphasis on their socio-economic characteristics, the impact of stated inputs on output and efficiency of labour-use according to three different farm sizes. It was found that the female farmers were relatively old and less literate; while the farmers were producing in the rational area of the production function, some inputs were being used in the irrational stage; farms of 2 hectares and above were the most efficient labour users. Programmes to improve rural welfare are recommended.

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The growing recognition of rural women's critical role in agricultural production in Nigeria has yet to be translated into action. Research has shown that rural women in Nigeria bear significant proportions of the workload in agricultural production. In addition, (Adeyokun, 1976; Spiro, 1981) Nigerian rural women are the principal producers of food and are mostly responsible for feeding the whole family. Boserup (1970) stated that rural women looked after agricultural production in subsistence agriculture especially in sub-saharan Africa which she referred to as "the region of female farming par excellence." FAO (1982) found that women constitute about 36 per cent of the agricultural labour force in developing countries on the average (Table 1).

Table 1: Sex Composition of Agricultural Labour Force

Region	No. of countries	Female as Percentage of Agricultural Labour Force
Sub-Saharan Africa	11	47.2
North Africa, Middle East	6	25.2
South, South-east Asia	5	40.2
Central, South America	8	19.0
Caribbean	2	54.0
Total	32	25.6

Source: FAO, 1982.

Invariably, women excel in their role as producers of food. These obligations translate into long working days for the women who make up more than half of Nigeria's rural population. In spite of their predominant role in agriculture, their productivity is constrained by restrictions on their access to technological improvements. Any agricultural development strategy should consider the economic significance of raising the productivity of the female labour force and ensure their equitable participation in the only processes of agricultural transformation.

Many related studies that have attempted to explain variations in technical efficiency have tended to focus on factors somewhat exogenous to the farmer's ability and control. Examples of such studies are Muller's work on the role of information (Muller, 1974) and Shapiro and Muller's (1977) study on the role of modernization. Specifically, the objectives of this study are to examine the socio-economic characteristics of the rural women farmers; to identify the influence of some variable factors namely farm size, planting materials, fertilizer pesticides, miscellaneous items, and labour on the output of the farmers; to examine the efficiency of labour-use by the farmers and to make policy recommendations based on the findings.

Agricultural development strategy should consider the economic significance of raising the productivity of the female labour force and ensure their equitable participation in the daily process of agricultural transformation.

Methodology

The study was conducted in Benue State of Nigeria in 1992. The choice of the area was based on the fact that it is predominantly an agricultural state and in fact, it is sometimes referred to as "the food basket" of Nigeria. Three hundred rural women, mostly widows and those with polygamous marriages, were randomly sampled from the four agricultural zones of the State comprising Central, Eastern, Northern, and Western zones. The women were mixed crop farmers, cultivating cassave, maize, and vegetables. Data were gathered through personal interviews using a set of pre-tested questionnaires. Descriptive statistics was used to example the farmers' socio-economic characteristics. The Cobb-Douglas production function analysis was employed to estimate the productivity levels of stated farm inputs on agricultural production. Kay's (1981) method of measuring labour efficiency was employed to examine the efficiency of labour-use by the farmers.

Results and Discussions

Nearly 97 per cent of the farmers were 50 years and above, while 3 per cent were less than 50, pointing to a relatively older generation of rural women in agricultural production. About 82 per cent of the farmers had some form of formal education. Whereas 2 per cent actually completed secondary school, 16 per cent had no formal schooling at all (table 2). Apart from credit granted to the farmers by money lenders, most of them finance their production from personal savings (78%), friends and relatives (22%).

Table 2: Level of Education (300 Rural Women Farmers)

Level of Education	Frequency	Percentage
No formal education	48	16.00
Incomplete primary school	143	47.67
Complete primary school	87	29.00
Incomplete secondary school	16	5.33
Complete secondary school	6	2.00
Total	300	100.00

Source: Field Survey Data, 1992.

The average farm size was 1.19 hectares. Fertilizer and pesticides were the most important input items accounting for about 30.16 per cent, and 42.54 per cent of total production costs respectively (Ranges 25.17% - 33.10%; 38.23% - 49.24%) (table 3).

Table 3: Per cent Input Costs in Agricultural Production (300 Rural Women Farmers)

Input	Farm Size (ha)			
	Less than 1.5	1.5-2.0	More than 2.0	All farms
Farmland	3.32%	3.10%	3.14%	3.19%
Planting Materials	3.48	4.12	4.59	4.06
Fertilizer	25.17	32.22	33.10	30.16
Pesticides	49.24	40.14	38.23	42.54
Miscellaneous items (bags, implements and organic manure)	16.36	18.26	18.87	17.83
Labour (family)	2.43	2.16	2.07	2.22
Total	100.00	100.00	100.00	100.00

Source: Field Survey Data, 1992.

Production Function in Agricultural Production

The Cobb-Douglas production function was used to relate the total farm output of the farmer's to the set of observed inputs used in the production process. The Cobb-Douglas function was used because of its importance in diagnostic analysis reflecting marginal resource productivities at mean levels of input use (Heady and Dillon, 1972). The double-logarithmic function was used because it gave a more useful result. The marginal physical products of the relevant variables were obtained by multiplying the b-coefficients with the relevant average physical products.

The generalized Cobb-Douglas production function used was:

$Y = a\, x_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} x_5^{b_5} x_6^{b_6} e$ (Upton, 1979), where Y = Total farm output in kg

x_1 = Farm size in hectares

x_2 = Planting materials in kg

x_3 = Fertilizer in kg

x_4 = Pesticides in kg

x_5 = Miscellaneous items in kg

x_6 = Family labour in man-days

a = Intercept

b_i = Elasticity of response of the $x_i th$ variable input

e = Stochastic error term with Ordinary Least Square (OLS) properties

The resultant model showed that:

$$Y = {}^{189.43}x_1 {}^{0.152}x_2 {}^{0.024}x_3 {}^{0.142}x_4$$
$$- {}^{0.029}x_5 - {}^{0.174}x_6 \, 0.047$$

S.E. = (0.771) (0.108) (0.157) (0.013) (0.872) (0.046)

t = (0.197) (0.222) (0.904) (2.231)* (0.429) (1.022)

MPP = (0.181) (1.153) (4.529) (1.219) (39.836) (34.224)

R^2 = 0.6842

F = 22.074**

S.E. = Standard error; t = t-statistic; *MPP* = Marginal Physical Product; R^2 = Coefficient of determination; *F* = F-statistic;

* = Significant at 5%; ** = Significant at 1%

Source: Calculation from Field Survey Data, 1992.

The result showed that the combined effects of farm size (x_1), planting materials (x_2), fertilizer (x_3), pesticides (x_4), miscellaneous items (x_5), and family labour (x_6) explained 68.42 per cent of the variation in output. This was significant at 1 per cent level using the F-statistic. The test of significance, which is the t-test of the b-values, showed that the quantity of pesticides used was significant at 5 per cent level. This implies that there was a negative impact of pesticides used on the output of the farmers at the present level of technology. Miscellaneous item expenditures also had negative (though not significant) impact on total farm output. Both the estimated regression coefficients and the t-tests for farm size, planting materials, fertilizer, and family labour were positive, although not significant at either the 5 per cent or the 1 per cent levels. Nevertheless, further analysis using their marginal physical products showed the following impacts of unit increases in these variables on total farm output of the farmers: farm size, 0.181 kg; planting materials, 1.153 kg; fertilizer, 4.529 kg; pesticides, 1.219 kg; miscellaneous items, 39.836 kg; family labour, 34.224 kg.

The result suggests that the farmers are producing in the rational area of the production function with regards to farm size, planting materials, fertilizer, and family labour but in the irrational area (stage III specifically) with regards to pesticides and the miscellaneous items. Also, the sum of the b-coefficients was less than unity, indicating decreasing returns to scale. Thus, at the present level of technology, efforts should be made to decrease pesticides and miscellaneous items while the use of improved planting materials and fertilizer should be encouraged and the optimum amounts obtained where their marginal physical products equaled their respective marginal factor costs.

Efficiency of Labour-use

The concept of efficiency is concerned with the relative performance of the processes used in transforming given input into output. Economic theory distinguishes between at least two types of efficiency—*allocative efficiency,* which refers to the choice of an optimum combination of inputs consistent with relative factor prices, and *technical efficiency,* which refers to the ability of an enterprise to employ the best practice in an industry so that not more than the necessary amount of a given set of inputs is used in producing the best level of output (Timmer, 1970; Carlsson, 1972). The degree to which these are achieved is commonly referred to as *production efficiency* (French, 1977).

Although many studies have been done on production efficiency in traditional agriculture with concentration on the allocative aspects (e.g. Sahota, 1968; Massel, 1968; Welsch, 1985; Norman, 1970), but not much has been done on labour efficiency with particular reference to women agricultural labour productivity, labour being the most expensive of all the farm productive resources in a labour-intensive economy.

Four approaches, based on Kay (1981), were used to evaluate labour efficiency (L.E.). These are (a) the value of farm production per person year (L.E.1); (b) farm size per person year (L.E.2); (c) Labour cost per naira of farm production (L.E.3); (d) Labour cost per hectare of land (L.E.4). These labour efficiency measures were applied to three sizes of farms (table 4).

For efficiency measures (L.E.1) and (L.E.2) (table 4), higher values implied greater labour efficiency, whereas for (L.E.3) and (L.E.4), lower values implied greater labour efficiency. The table showed, for example, that one labourer produced food worth N624.26 (farm size less than 1.5 ha), N938.47 (farm size 1.5-2.0 ha) and N1219.23 (farm size greater than 2.0 ha) while the average labourer in all the farms produced N927.32 worth of food. This meant that using this labour efficiency measure, the most efficient farms were those greater than 2.0 ha while the least efficient were farms less than 1.5 ha. Farms above

Table 4: Labour Efficiencies According to Farm Size (300 Rural Women Farmers)

Labour Efficiency Measure	Unit	Farm Size (ha)			Average Labour efficiency for all the farms
		Less than 1.5	1.5.-2.0	More than 2.0	
Value of farm production per person year (L.E. 1)	N*	624.26	938.47	1219.23	927.32
Farm size per person year (L.E. 2)	ha	0.62	1.82	2.97	1.80
Labour cost per naira of farm production (L.E.3)	N	0.32	0.28	0.17	0.26
Labour cost per hectare of land (L.E. 4)	N	396.24	217.75	108.03	240.67

* = 15 Naira (N 15) ≡ 1 US Dollar ($1)
Source: Calculations from Field Survey Data, 1992.

2.0 ha were also the most efficient labour users with regards to farm size per person year (L.E.2), labour cost per naira of farm production (L.E.3) and labour cost per hectare of land (L.E.4). These were followed by farms of 1.5-2.0, and less than 1.5ha, respectively, for (L.E.2), (L.E.3), and (L.E.4). From the data, 16.67 per cent of the farmers had farms above 2.0 ha, 40.00 per cent had farms of 1.5-2.0 ha, while 43.33 per cent operated farms less than 1.5 ha. It could, therefore, be said that in terms of L.E. 1, L.E. 2, L.E. 3, and L.E. 4 efficiency measures, 16.67 per cent of the farmers were efficient labour users, 40.00 per cent were moderately efficient labour users, while 43.33 per cent were poor labour users. Therefore, based on labour efficiency, the minimum recommended farm size for agricultural production should be two hectares.

Conclusions & Policy Recommendations

Under the present level of technology and output, pesticides use should be reduced, or costs subsidized. Alternatively, cultural methods of pest control – ploughing, adequate spacing and correct seed rate per hectare, timing of planting, and frequency of weeding – should be adopted, especially in this period of Structural Adjustment Programme (SAP) where the cost of agro-chemicals (pesticides) is very high in the country. Use of pesticides would become critical only when there is massive infestation. Further, farms of two hectares and above have been shown to be more efficient labour users than small farms. Thus as a policy measure, a minimum farm of 2.0 ha should be encouraged. Since the productivity of these farmers is low, the government of Nigeria should formulate means of raising their productivity. These include, not merely access to agricultural credit and land, but also access to gender (female) oriented agricultural technologies. The specific needs of rural women in Nigeria should be treated with priority. These should not be seen merely as "Women Power", "Women Liberation Programmes. They should be properly understood as programmes aimed at using women to solve a major national problem. The Better Life for Rural Women Programme and the National Commission for Women Affairs established by the Nigerian government are steps in the right direction, but should not be allowed to be used as career spring boards by remote urban elites.

References

Adeyokun, T.C. (1976), "Agricultural Development Education and Rural Women in Nigeria". *Paper presented at the conference on Nigerian Women and Development in Relation to Changing Family Structure*. University of Ibadan, Nigeria.

Boserup, E. (1970), Women's Role in Economic Development, New York, St. Martin's Press.

Carlsson, B. (1972), "The Measurement of Efficiency in Production: An Application of Swedish Manufacturing Industries." *Swedish Journal of Economics*, Vol. 74, No. 4.

FAO (1982), "The Role of Women in Agricultural Production" Committee on Agriculture, Food and Agriculture Organization of the United Nations, Rome, Italy.

French, B.C. (1977), "The Analysis of Productive Efficiency in Agricultural Marketing: Models, Methods and Progress," in a Survey of Agricultural Economics Literature, Vol. 1 — Traditional Fields of Agricultural Economics, 1940's to 1970's Less, R. Martin, Editor University of Minnesota Press.

Heady, E.O. & Dillon, J.L. (1972), Agricultural Production Functions, Ames, Iowa, State University Press.

Kay, R.D. (1981), Farm Management, New York, McGraw Hill Company.

Massell, B.F. (1968), "Farm Management in Peasant Agriculture" Food Research Institute Studies, Vol. 7, No. 2.

Muller, J. (1974), "On Sources of Measured Technical Efficiency: The Impact of Information." American Journal of Agricultural Economics, Vol. 56, No. 4 November.

Norman, D.W. (1970), "Initiating Change in Traditional Agriculture." Proceedings of the Agricultural Society of Nigeria, Vol. 7.

Sahota, G.S. (1968), "Efficiency of Resource Allocation in Indian Agriculture." American Journal of Agricultural Economics, Vol. 50, No. 3.

Shapiro, K.H. & Muller J. (1977), "Sources of Technical Efficiency: The Roles of Modernization and Information." Economic Development and Cultural Change, Vol. 25.

Spiro, H.M. (1981), "The Fifth World: Women's Rural activities and Time Budgets in Nigeria." Occasional Papers No. 19. Occasional Papers in Geography. Department of Geography, Queen Mary College, University of London.

Timmer, C.P. (1970), "On Measuring Technical Efficiency," Food Research Institute Studies in Agricultural Economics, Trade and Development, Vol. 9, No. 2.

Upton, M. (1979), Farm Management in Africa, Oxford University Press.

Welsch, D.E. (1985), "Response to Economic Incentives by Abakaliki Rice Farmers in Eastern Nigeria" Journal of Farm Economics, Vol. 47, No. 4 □

Inter-Regional Variation in Agrarian Labour Productivity – Case Study of Tamil Nadu

D. Suresh Kumar & C. Ramaswamy

This paper examines the variations in labour productivity across regions through its components viz., yield, cropping intensity and man-land ratio by using three stage least squares (3SLS) simultaneous equations approach. The study was carried out in two different irrigation environments. The analysis lucidly shows that the marginal labour productivity is positive and relatively higher in favourable environments. Man-land ratio, fertilizer and cropping pattern index are the major factors influencing variations in yield. Level of cropping intensity is determined by the same set of factors irrespective of the environments. Cropping intensity is the single factor which explains variations in man-land ratio across all regions. Policy implications include development of major and minor irrigation, net sown area and net irrigated area, increased use of yield augmenting inputs, proper education on employment avenues and effective population control measures to improve the labour productivity.

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In the past four decades of planned development, India has achieved spectacular increase in food grain production. The area under irrigation has increased significantly. Consumption of fertilizers has stepped up manifold. However, the overall gains have not been shared equitably, particularly by the landless agricultural labourers, who form the largest segment of forming sector of the economy. Per capita labour productivity is very low when compared to other developed countries. According to recent statistics, the labour productivity in our country is Rs. 1213, whereas it is $ 3495 in West Germany, $ 3481 in New Zealand, $ 2408 in U.S.A. and $ 2265 in Japan. This low labour productivity is mainly because of high man-land ratio which in turn is due to factors like the demographic addition to the labour force, lack of employment avenues in the rural non-agricultural sector, and lack of adequate population control measures. Also, considerable variations exist in the levels of labour productivity across regions. For example, the labour productivity varies from Rs. 409 in Nagaland to Rs. 3195 in Punjab. This variation in the labour productivity is because of sharp variations in the constituent components of labour productivity, viz., yield, cropping intensity and land-man ratio.

For the present study it has been hypothesised that the marginal productivity of labour is positive that the removal of labour input would decrease the total output, but this fall would be small and could be offset by an increase in the quantity of other inputs; and that the labour productivity and the different factors influencing the constituent components of labour productivity vary across regions. In order to study these hypotheses, the following objectives are framed: estimating the labour productivity and marginal productivity of labour inputs across regions, examining the various factors influencing variations in the constituent components of labour productivity across regions and prescribing policy measures to increase the labour productivity and to reduce its regional variations.

Table 2: Estimates of 3SLS Simultaneous Equation Model

Equation	Variables	Situation I	Situation II	All
YIELD	MLR	0.38838* (4.347)	0.48852 (1.567)	0.53610* (3.5642)
	FERT	0.03102** (2.088)	0.31562* (3.942)	0.24621* (2.815)
	GROIRR	0.81621* (5.627)	0.56191** (2.546)	0.85961 (1.538)
	CRPTI	1.56521* (6.264)	1.42568* (4.384)	2.54310** (2.464)
	CONSTANT	3.59684 (1.126)	2.35648 (1.567)	0.69432 (0.565)
CROPINT	MLR	0.01929* (3.329)	0.21692* (2.967)	0.43218* (4.612)
	NETIRR	1.0036* (14.362)	.13547* (2.589)	0.26784* (3.518)
	IRRINT	0.07657** (2.490)	0.24356* (5.164)	0.94186* (3.205)
	CRPTI	0.14143* (2.782)	0.11419* (4.206)	1.0058* (3.005)
	CONSTANT	0.95677 (.5678)	0.96645 (.96645)	0.84659 (.8461)
MLR	CROPINT	0.98399* (12.397)	0.85641* (4.1652)	0.69310* (2.431)
	NETIRR	1.04838 (1.523)	2.00359* (6.005)	4.16952** (2.085)
	TRACTOR	–0.28625** (–2.626)	–0.19563* (–4.521)	–0.56928* (–.3.568)
	GROCRA	1.21864 (1.923)	0.24961* (3.334)	0.56830* (2.085)
	CONSTANT	1.95674 (0.8548)	0.34894 (1.894)	1.84631 (1.043)

Note: (a) Figures in the parentheses indicate estimated 't' values.
(b) Level of significance of 't' values; * = $p < 0.01$, ** = $p < 0.05$, *** = $p < 0.10$

Tractor power has a significant negative influence on man-land ratio. It firmly supports that the use of more tractor power reduces the human labour absorption. The factors, net irrigation, gross cropped area do not have any significant influence on the man-land ratio. However, in situation II they have a significant positive influence on the man-land ratio as we expected. The variable factor power shows significant influence on the labour availability on the expected line.

Conclusion

It is evident from the analysis that the inputs labour, land and capital significantly influence the gross income. The estimates of 3SLS simultaneous equations model indicate that the man-land ratio, fertilizer, cropping pattern index are the major factors influencing variations in yield. Man-land ratio is the most prominent factor. Except man-land ratio all the other explanatory variables explain variations in aggregate yield in less favourable environment. It could be concluded that the level of cropping intensity is determined by the same set of variables irrespective of the environment. Cropping intensity is the single dominant factor explaining variations in the man-land ratio across all regions. Tractor power shows significant negative influence on the man-land ratio.

Since the labour productivity and various factors explaining variations in the constituent components of labour productivity vary across regions, the policy for increasing labour productivity and reducing the inter-regional variations have to be formulated separately for high and low labour productivity regions. Development of major and minor irrigation, net sown area and net irrigated area will substantially increase the labour productivity. Increased use of yield augmenting inputs like HYV seeds, fertilizer also augment labour productivity. Proper rural education schemes on employment avenues in non-farm sector in urban areas and inter-regional migration should be done effectively in order to reduce the population pressure on land in the rural sector. Effective population control measures and increased non-farm employment avenues in rural areas may be taken up to increase the labour productivity which in turn will reduce rural poverty. □

Optimal Crop-Livestock Mix in Garden Land Farms of Tamil Nadu

A. Kandaswamy & R. Venkatram

In garden land tracts, considerable scope exists for improving the income and productivity of farms through appropriate changes in the crop-livestock nexus. The authors carried out a research project to test this hypothesis in Coimbatore district of Tamil Nadu and present their conclusions in this article.

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In garden land farms, crop production and livestock rearing are the major production activities. Resource allocation among these enterprises in the farms is constrained by many technical and socio-economic factors. Inflicting a high degree of restriction on productivity, thus leading to sub-optimality. Studies conducted in different farm situations by Amrik and Sidhu (1977), Sharma and Tewari (1985), Satheesh et al (1985), Manjeet Kaur and Sankhayan (1986), Chatterjee (1988), Sankhayan *et. al* (1988) and Aswini Kumar and Pandey (1988) have analysed the extent of constraints at the farm level and explored the possibilities of increasing the farm productivity, income and employment through different planning techniques. However, very little work has been done in analysing the joint relationship of crop and livestock nexus especially in garden land tracts. With the above observation, a workable hypothesis that there existed considerable scope for improving the income and productivity of farms through changes in the crop and livestock plan at the given level of technology was formulated and tested in the present study.

Sampling

This study was carried out in Annur block of Coimbatore district of Tamil Nadu. The block is a typical garden land tract wherein farming is done by tapping underground water. Availability of irrigation water sets the cropping pattern, and influences the productivity of crops and the extent of risk and uncertainty. Owing to drop in the water table mainly due to digging of new wells outstripping the potentials and frequent failures of monsoon, the crop cultivation has been seriously affected. Hence, to minimise the income uncertainty, livestock enterprise is becoming a popular enterprise mix in the farming system. However, the optimal number of animals to be maintained depending on the resource limitations is yet to be fixed. Therefore, the block is purposively selected to conduct the study. By random sampling technique, forty five farms were selected. From these farms, a typical farm, which could represent most of the other farms based on resource endowment, was chosen to develop an optimal farm plan.

Availability of irrigation water sets the cropping pattern, and influence the productivity of crops.

Technological Matrix

The technological matrix for the linear programing was constructed using cross sectional data (survey data) collected through interview schedules. Various crop and livestock activities were identified and the requirement of resource 'i' to produce one unit of activity 'j' was estimated for each crop and livestock activity from these data. Resource constraints viz., land (monthwise), capital (working capital), minimum area allocation for fodder producing crops like sorghum and water availability (monthwise) were specified. Finally, the model consisted of 22 crop activities, one livestock activity (milch animal) and a labour hiring activity in the objective function. The number of resource constraints identified amounted to 30. Output levels of various producing crops were also estimated. Such outputs were transferred to livestock enterprises, as fodder. The cost coefficients were the net income form the various crop and livestock activities. Labor was specified as hiring activity and the requirement of labour for the plan was estimated within the model itself.

Model

The following mathematical model was used to derive optimal farm plan.

$$\text{Maximize } z = \sum_{j=1}^{N} C_j\, x_j - \sum_{k=1}^{N} W_k - H_k$$

subject to

$$\sum_{j=1}^{N} am_j\, x_j \le Am \text{ (land constraint } m = 1, 2, 3, \ldots 12)$$

$$\sum_{j=1}^{N} I_{ij}\, x_j \le I_j \text{ (irrigation constraint } i = 1, 2 \ldots\ldots 12)$$

$$\sum_{j=1}^{N} k_j\, x_j \le K_j \text{ (working capital constraint)}$$

$$\sum_{j=1}^{N} l_j\, x_j \le L_j \text{ (irrigated land constraint)}$$

$$\sum_{j=1}^{N} g_i\, x_j \ge G_j \text{ (minimum area constraint for sorghum)}$$

(which will take '0' value for other crops)

$$\sum_{j=1}^{N} d_j\, x_j - H_k = 0 \text{ (labour constraint)}$$

$$\sum_{j=1}^{N} f_j\, x_j - T_k = 0 \text{ (Animal feed transfer from fodder producing crops)}$$

z	=	total net return
C_j	=	net income from jth activity
x_j	=	the level of activity 'j'
am_j	=	coefficient of land for jth activity in month 'm'
Ii_j	=	coefficient of irrigation water for jth activity in month 'i'
k_j	=	coefficient of working capital requirement for jth activity.
l_j	=	coefficient of land for j^{th} activity for irrigated crop
g_j	=	minimum area to be allocated for crop 'sorghum' and '0' for other activities.
d_j	=	human labour (man days) required j^{th} activity.
f_j	=	yield of fodder from fodder producing crops and '0' for other crop activities.
W_k	=	Wage rate for labour per day (Rs)
H_k	=	Units of human labour hired
A_m	=	area (ha) available in month 'm'
I_i	=	Irrigation water available in month 'i'
K_j	=	Working capital available (Rs)
L_j	=	Area (ha) of irrigated land available
G_j	=	Minimum area allocated for crop
T_k	=	Per animal fodder requirement

Results

In order to provide the background information about the farm households, the socio-economic features of sample farms were studied. The characteristics are presented in table 1.

Table 1: Socio-Economic Features of Farms

(Averages)

Characteristics	Values
Family Size	4
Income from agriculture (%)	90.40
Literacy rate (%)	57.64
Size of farm holding (hectares)	2.29
Number of milch animal	1
Extent of commercialization in cropping pattern (%)	36.91
Percentage of gross cropped area to operated area	120.04
Percentage of gross irrigated area to gross cropped area	38.11
On-farm employment (days/year)	
Men	278
Women	138
Children	27

It could be seen from table - 1 that the average family size of the sample farm was four persons. The family derived income from agriculture predominantly. The literacy level was 57 per cent. The average size of holding operated by the farms was 2.29 hectares and the tenurial pattern was owner cultivation. The cultivable land is classified as garden (irrigated by wells) and dry (rainfed). In the study area, the farms had a combination of both garden and dry lands. Livestock is a major supplementary enterprise to crop activity and the farms maintained atleast one milch animal.

The extent of commercialization as measured in percentage of area under commercial crops (sugarcane, cotton, groundnut etc) to total cropped area is estimated at 37 per cent. This could imply that farmers preferred to cultivate more of non-commercial crops. (food and fodder crops). The percentage of gross cropped area to operational area was 120 indicating that the land was put into use only in a year. The irrigation coverage was very low as only 38 per cent of the area was irrigated out of the total cropped area. Agriculture remains the major source of employment for the farm households and the annual employment generated through various farm activities were 278, 138 and 27 days per farm for men, women and children respectively.

Existing Farm Plan

Prior to developing optimal farm plan, the existing farm plan was studied in detail. In the study area, crop cultivation in different seasons is determined by the onset of monsoon rains and the availability of water in wells thereafter. Three distinct seasons were identified viz. *Adi Pattam* (July to December). *Thai Pattam* (January to March) and *Chithirai Pattam* (April to June).

In the first season, under rainfed condition, sorghum, groundnut, cotton, rnaize and horsegram were the principal crops cultivated. In the second season, sorghum, samai and groundnut were cultivated. Gingelly was the predominant crop cultivated in the third season. Under irrigated condition, cotton, maize, paddy, turmeric, tomato and sorghum were cultivated during the first season. In the second and third seasons, paddy, sorghum and tomato were cultivated. Sugarcane crop was cultivated throughout the year and area allocation was based on the availability of irrigated water.

In the typical farm situation, the existing plan of the farm had crop and livestock activities. Sorghum (0.40 ha), greengram (0.10 ha), sugarcane (0.30 ha) and forage crop (0.10 ha) were the crops cultivated. The farmer maintained four milch animals and a pair of work bullocks. The crop and livestock enterprise realised a net return of Rs. 3648 during the production year.

Optimal Plan

Using the data, the optimal farm plan was derived by applying the linear programming technique. The results of the optimal solution were then compared with the existing plan in order to explore the possibilities of improving the farm income and productivity of farm resources through an optimal crop-livestock mix. The results are presented in table 2.

In the optimal plan derived, sorghum with greengram (1.26 ha), gingelly (1.01 ha), blackgram (0.26 ha), tomato (0.10 ha), groundnut (0.61 ha) and sugarcane (0.20 ha) were the crops suggested. This crop sequence along with four milch animals could generate a net return of Rs. 14,186, i.e an addition of Rs. 105.38 over the existing return.

Plan Feasibility

The existing level of resource utilization particularly land, reveals that the farmers wanted to maximise the profit by intensively making use of the available inputs especially water. In order to achieve this, a portion of the irrigated land was even left fallow and the criterion was to allocate the inputs to limited area instead of the entire farm area. Such allocation is not always efficient and thus the optimal farm plan has suggested redistribution of the resources in the irrigated land among relatively less water exacting and remunerative crops.

Table 2. Existing and Optimal Farm Plan

Particulars	Existing	Optimal	percent of change
Area available for Cultivation (ha)			
(a) Irrigated	0.91	0.91	
(b) Dry	1.01	1.01	
	1.92	1.92	
Cropped area (ha)			
(a) Irrigated			
Tomato	—	0.10	
Groundnut	—	0.61	
Sugarcane	0.30	0.20	
Forage crops	0.10	—	
	0.40	0.91	
(b) Rainfed (ha)			
Sorghum	0.40	—	
Sorghum + Greengram	—	1.26	
Gingelly	—	1.01	
Blackgram	—	0.26	
Greengram	0.20	—	
	0.60	2.53	
Land Use efficiency (%)	52.08	179.32	127.24
Commercialization (%)	30.00	52.86	22.86
Livestock (No)			
Milch animals	4	4	
Work bullock	2	—	
Net return (Rs.)	3648.50	14186	288.00

Similarly, in dry land, the farmers have the general practice of cultivating only one crop and depending on the distribution of rains a few more crops were raised. The optimal plan suggested two crops a year but only in limited area. This possibility is limited to the extent of receipt of rain during summer months. Thus to examine the technical feasibility as well as acceptability of optimal plan to farm level, the results were discussed with the farmers. The crops suggested in the optimal solution were generally acceptable. However, most of the farmers wanted to maintain a pair of work bullocks. Despite its low income generating capacity compared to milch animal, a very strong preference for maintenance of work bullocks was observed. Hence the optimal plan was revised to include the pair of work bullocks by substituting two milch animals and found acceptable at farm level. The net return after inclusion of work bullocks was estimated to be Rs. 13434, without any change in the crop sequence.

The existing level of resource utilization particularly land, reveals that the farmers wanted to maximise the profit by intensively making use of the available inputs especially water.

Conclusion

The result and evidences of the study indicated that there is a need to refine the production plans of farms to cope with the changes in technology and in the socio-economic environment. The crop–livestock enterprise nexus needs to be identified critically in these tracts. There is also a need to strengthen a multi agency approach towards scientific crop and livestock planning if one is to achieve a better productivity of farm resources.

References

Amrik, S. Saini & D.S. Sidhu (1977) "Impact of Dairy Enterprise on farm income in Punjab", Journal of Research Vol. XIV No. 2.

Aswini Kumar Sarma & Roop Narayan Pandey (1988) "Capital Requirement for Modernisation of Agricultural Production in Haryana in 2000 AD", Indian Journal of Agricultural Economics, Vol. 43 No. 3, July-Sep.

Chatterjee (1988) "Net Returns Optimization through resource efficiency analysis of crop mixes: An experiment for Royalseema small farms" Indian Journal of Agricultural Economics, Vol. XLII No. 1. Jan-March.

Manjeet Kaur Cheema & P.L. Sankhayan. (1986),"Estimation of Capital and Credit Needs", Financing Agriculture, Vol. XVIII No. 3-4

Sankhayan, P.L.: R.S. Prihar & H.S. Cheema (1988) "Developing Optimum Cropping Plans for a typical Punjab farm with multiple objectives using compromise programming", Indian Journal of Agricultural Economics, Vol. XLIII, No. 2, April-June.

Satheesh A.V., B.M. Sharma & V.K. Sharma (1985) "Impact of Diversification and liberal credit policy on income and employment of non-viable farmers in Pithapuram block of East Godavari District", Indian Journal of Agricultural Economics, Vol. XL, No. 3, July-Sept.

Sharma, L.R. & Tewari S.C. (1985) "Effective use of resources in farming" Productivity Vol. XXV, No. 4. □

Consequences of Declining Fallows: Case Study from Anambra State, Nigeria

Eric. C. Eboh

This paper traces the historical trend of fallow decline and the consequences on the agro-ecology and crop productivity in Anambra State of Nigeria. A farm survey was conducted during 1989 in Edem, Obollo-Eke and Oduma communities in the State to elicit contemporary evidence regarding the relationship between fallow decline and farm yields. It was observed that fallow decline correlated directly with crop yields from farming. If unchecked, progressive soil fertility loss and associated productivity decline will continue to pose real danger to agricultural growth and sustainable development. One way out is to promote soil enhancing techniques such as the use of organic and inorganic manures. Problems of non-access to soil manures, poor knowledge of appropriate types and quantities to use as well as the constraints posed by unsustainable soil management techniques need to be addressed by small farm policy planners and practitioners.

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The bush fallowing system of agricultural land use has for centuries been practised by African smallholders to preserve agro-ecological balance while maintaining yields at acceptable levels. Since land was relatively abundant then, fallow periods were long enough to bring back denourished soils to nearly original levels. Today however, increased population pressure, and agricultural commercialization have forced reductions in fallow periods to rather intolerable levels. The agro-ecological and productivity impacts of this emerging trend is of great concern to agricultural policy makers, farm scientists and the agricultural community as a whole.

Fallow Decline: A Historical Overview

In Anambra State, and elsewhere in southeastern Nigeria, traditional farming systems have historically relied on shifting cultivation or rather bush fallow technique for maintaining the fertility and productivity of arable lands. By using skillful methods in farm site selection and cultivation based on experience, smallholder crop farmers ensured the balance between their socio-economic and agro-ecological environments (Moutappa, 1974).

Under the bush fallowing system, a short cropping phase alternates with a longer resting period during which soil nutrients are replenished and the agro-ecology re-established. During the resting period, fertility is restored to an extent determined collectively by the length of the fallow, the nature of the vegetation and the soil. The soil humus is increased during the fallow period, chiefly as a result of the fall of litter from regenerated vegetation (Webster & Wilson, 1980). In the forest areas characterised by rapid regeneration of vegetation, large amounts of nutrients are quickly accumulated in the secondary forest growth and the fallows were long enough to restore fertility nearly to its pre-cropping levels. Prevailing high rainfall regimes and high temperature conditions further enhanced the effectiveness of the forest fallows. But in the Savanna and Woaland areas with their characteristic low rainfall and marked dry season, the fallows were less effective as environmental stabilizers. This was as expected since the post-fallow organic matter and nitrogen content of savanna soils were hardly capable of supporting the subsequent cropping phase. Slow regrowth of vegetation and lack of moisture to enhance soil biological activity were the major reasons.

Like in other areas, fallow systems in Anambra State have been subjected to a wide variety of pressures ranging from the socio-economic to the demographic. The high rates of population growth in the State access to technical innovations, the growth of urban and rural purchasing power, government interventions are changing market relations put pressure on the fallow system. These developments are accompanied by institutional, cultural and social changes (Rutherberg, 1960). Despite some uncertainty as to the precise weight of the individual pressures in the fallow decline function, it is common knowledge that population growth has imparted enormous consequences on fallow management. Increased population pressure has caused severe land shortages in parts of Anambra State in particular and southeastern Nigeria in general. It is believed that there exist acute land shortages in Imo and Anambra States of Nigeria where population densities rank among the highest in rural Africa (Legemann, 1977; Ruthernberg 1980).

Thomas Malthus put the land shortage problem in a global economic perspective when in 1798, he postulated that continuing population growth would destabilise the agricultural system and bring about economic stagnation and environmental doom. Even though the Malthusian doctrine has been criticised and sometimes dismissed outrightly in latter works, the fact remains that land shortage poses an apparent (if not real) threat to agricultural growth and environmental systems in parts of sub-Saharan Africa. This is in spite of Ester Boserup's thesis that population pressure and land shortage would exert positive developmental benefits on the agricultural system through a mechanism of adaptations. Ester Boserup had argued in 1965 that increasing population pressure would cause agricultural systems to progress along a continum of farms ranging from forest fallow through bush and short fallow to annual cropping. And that as forest fallows evolve towards shorter follows, changes would occur in agricultural techniques. The result ofcourse would be technological transformation of the agricultural system which most argumentatively implies upward shifts of farm production functions. The unfolding trend in Anambra State betrays this argument. Besides, the linear progression theory of Boserup has been strongly criticised for its unicausal conceptualization of agricultural change and for its neglect of inertia in the mechanism of adaptation.

Continuing population growth would destabilise the agricultural system and bring about economic stagnation and environmental doom.

Today in Anambara State, fallow periods have shortened with little or none of those attributes alluded to by Boserup. Acute land shortages in scattered parts of the State seem to have forced smallholder farmers to abandon (either partially or completely) the environmental stabilizing system of bush fallowing which they had practised rather successfully in the distant past. The switch from long to short fallows is however far from being an overnight phenomenon as evidenced by the co-existence of fallows of different periods in the agro-eco-system. The evolutionary trend more or less appears to have assumed a gradual process of alteration in the fallow management.

As population pressure increases and the fallow period shortens, there comes a growing need for non-fallow techniques of stabilising the soil environment in order to ensure future continuity and improvement of crop yields (Migot-Adholla, et al., 1991). Invariably, the decline implies a substitution of labour for land that is akin to Boserup's 'increased labour input per hectare' postulate. Additional labour input would be required to carry out soil fertilizing and land preparation operations, land improvement investments such as destumping, levelling etc. (Platteau, 1988). Possibilities for substituting labour for land as fallow declines however hinge on the availability of the material for land operations, farmers' access to these materials and than farmers' knowledge of associated technologies of usage.

Repercussions on Productivity and Agro-Ecology

Until recently, fallow decline did not worry agricultural scientists and environmental officials. This is because according to its ancient operationalisation, the fallow system posed no serious environmental threat. Soil fertility was rather adequately restored and land degradation was minimal. Crop yields were also maintained at stable albeit low levels just sufficient for subsistence. But in Anambra State, increased population pressure appears to have rendered restorative fallows critically shorter and in extreme cases almost impracticable, with the result that soil fertility and crop yields have greatly declined and land degradation aggravated (Eboh et al, 1990). Here lies the environmental hazard of fallow decline. Such a bleak trend if allowed to continue would portend worse environmental consequences which may be more difficult to reverse.

So without appropriate and adequate soil management and land conservation regimes, fallow decline can cause great ecological damage. Widespread ecological damage is not only detrimental to present and future crop yields but also undetermines the survival and security of the people. The problem of environmental degradation is more pronounced in the humid rainforest areas (as found in parts of the State) where there occur high levels of weathering and considerable ecological sensitivity to man's interference through cultivation. Examples of such sensitivity include the increased incidence of weed infestation and pests and diseases implied under shorter fallows or long cropping periods (Ruthernberg, 1980, Biswanger & Pingali, 1987).

Without appropriate and adequate soil management and land conservation regimes, fallow decline can cause great ecological damage.

But with adequate land management, environmental quality will be preserved despite fallow decline. At the same time, yields will be saved. Environmental protection and yield sustenance are both important considering that the land must supply the growing needs of rural and urban peoples in spite of the increasing use of synthetic products. The land resource is unlikely to continue supplying its products unless a just and proper balance is achieved between its exploitation and conservation. Environmental conservation in the land context ensures optimal resource exploitation in accordance with long term sustainability requirements. Otherwise, ecological damage may occur with the expansion of impoverished smallholder farming producing unfertilized arable crops on depleted soils in Anambra State and elsewhere. Other environmental hazards will be manifested deforestation, loss of game and serious erosion.

Farm Level Survey

Empirical evidence was sought through a farm level survey undertaken to elicit the relationship between the effect parameter (crop yields/soil fertility) and the cause factor (fallow length). Two hundred small farmers were randomly selected in a total of three communities across two agricultural zones in Anambra State. For each former, a near field and a distant field (defined from the farmer's trekking distance perception) were studied thus giving a total of four hundred farm fields. Only those fields in the cropping phase of the cultivation cycle were investigated, since emphasis was on arable crop yields and the pre-cropping fallow periods. The reference period was 1989 farming year. Obollo-Eke (239 person per sq. km) was chosen to represent a situation of relative land abundance whereas Edem (815 persons per sq.km) represents a case of land scarcity. Midway between the two situations is Oduma with population density of 484 persons per sq. km.

Data obtained related to fallow periods, crop yields, soil management cropping techniques, cropping periodicity and agro-ecological conditions. Simple regression analysis was carried out to estimate the effect of fallow length (F_L) on gross physical yields:

$$Y_1C = f(F_L)$$

where Y = yam output per hectare; C = cassava output per hectare.

Effect of Fallow Length on Crop Productivity: Yam and Cassava

The estimated regression functions showing the effect of fallow length on economic returns were as follows.

Obolle-Eke	Y = 5018.63 (715.04)	+ 133.65 F_L; 56.87)	R^2 = 0.43
	C = 4672.00	+ 102.61 F_L; (51.08)	R^2 = 0.21
Oduma	Y = 5126.51 (226.02)	+ 226.02 F_L; (99.65)	R^2 = 0.23
	C = 4413.53 (506.37)	+ 236.98 F_L;, (90.10)	R^2 = 0.25
Edem	Y = 3716.07 (500.30)	+ 327.35 F_L; (107.32)	R^2 = 0.36
	C = 4044.92 (507.27)	+ 102.06 F_L; (44.1)	R^2 = 0.24

where Y, C and F_L are as earlier defined figures in parantheses are standard errors.

The above regression estimations show that fellow length significantly effected yam and cassava yields in the three communities. The higher (or lower) the fallow length, the greater (or smaller) the per hectare output of yam and cassave. The elasticity of land productivity of yam and cassave to changes in fallow length (as suggested by the individual R^2 values) were: 43, 23 and 36 per cent for yam yields in Obollo-Eka, Oduma and Edem respectively; whereas those for cassava yields were 21, 25 and 24 per cent in Obollo-Eke, Oduma and Edem, also respectively. Elasticity values here imply the percentage change in the per hectare output of yam or cassava resulting from a percentage change in fallow period. When the figures are viewed from the other side, they suggest that fallow decline constrained land productivity of yam and cassava in all the three communities.

The highest explanation of yield variability by fallow length was observed in Obollo-Eke since the farmers there enjoyed relative land abundance which accentuated extreme fallow values. Among the three cassava yield regression functions, Obollo-Eke had the greatest intercept and Edem and smallest. If these intercept values are interpreted to indicate the levels of technical productivity (Eboh, 1987) the Obollo-Eke equation showed yield superiority and hence greater technical or physical productivity than those for the other two communities. This implies that for similar levels of input-mix, the obollo-Ekefarm scenario proruof output; not surprising considering that fallow periods were significantly longer here than in the other two communities - Oduma and Edem. Hence, the emergent evidence is that farms with longer pre-cropping fallow periods tended to be more productive than those having shorter fallow periods. This relationship was maintained in the yam yield regression functions – the greatest value of intercept was in Obollo Eke and the smallest value was in Edem.

Extrapolating the analysis to the aggregate yield in the mixed-crop system, the yam and cassava evidence were corroborated. Taking gross farm returns (in naira) from all the crops grown on the farm, the effect of fallow length was similarly estimated. Of course, for both the yam and cassava estimations and the gross returns valuation, a homogeneity of farm management regimes and agro-ecological conditions was assumed considering the need to isolate fallow impact and also the fact that all farmers studied were small holders under a similar agro-ecological, socio-economic and micro-management conditions.

The regression of gross farm return (per hectare) on fallow length gave the following results.

Obolle-Eke	GFR =	14096.96	+ 264.82 F_L;	R^2 = 0.14
		(2360.34)*	(103.49)	
Oduma	GFR =	6726.77	+ 1245.24 F_L;	R^2 = 0.17
		(1665.97)	(589.43)	
Edem	GFR =	10046.71	+ 1084.51 F_L;	R^2 = 0.15
		(2016.10)	(178.91)	

* () = Standard error of coefficient.

As shown, fallow length produced significant positive impact on gross farm returns per hectare (GFR) in naira. This claim hinges an the successful statistical test of coefficients using the level of significance - 5 per cent. But the explanatory power of the fallow length (standing for elasticity of gross farm returns) was less than in the crop-specific equations. This was probably because of the incremental effects of non-fallow factors in the mixed-crop system. Put in the other way, fellow decline affected negatively the gross farm returns per hectare. Considering that gross farm returns proxied an imaginary agro-ecological impact, it could be claimed tht fallow decline constrained agro-ecological sustainability. After all, the losses in soil fertility concommitant upon fallow decline have been assumed, even though, not proportionately, to translate into reduced gross farm returns per hectare.

Losses in soil fertility concommitant upon fallow decline translate into reduced gross farm returns per hectare.

Reversing the Productivity Decline Effects of Shortening

Soil fertility loss and the consequent productivity decreases which have been associated with fallow decline point to the growing threat of intensified land use to the agricultural system. Such environmental degradation effects could swell up to crisis levels unless adequate farm level interventions are carried out to reverse or ameliorate the trend. Small farm planners would have to design strategies to ease smallholders' access to adequate amounts of organic and inorganic manure such as green manure, household refuse, ashes, compost, animal manure, oil-seed residues and artificial fertilizers. There are constraints as well as opportunities to the use of these manuring techniques. Policy actions should ameliorate these constraints and thereby boost the opportunities that exist for environmental sustainability. For example, the scarcity of labour to prepare and apply manuring materials can be eased when farmers obtain production credit to hire more labour. Also the shortage of manuring materials can be alleviated when extension workers teach farmers how to 'cheaply' generate manure from daily farm operations especially considering that most farmers lack the technical know-how to generate and store their own manure. Through this, the indiscriminate burning-up of potential manuring materials would be minimised and there will be upward shifts in manure availability. The situation of the fallow progression from longer to short periods should be countered with appropriate and adequate soil management and land conservation methods. Greater use of organic and inorganic manures would be the way out after the farm level constraints including the lack of access to manuring materials, poor technical know-how and labour shortages are alleviated.

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References

Biswanger, H.P. and **P.L. Pingali**, (1987). "The Evolution of farming systems and agricultural technology in Sub-Saharan Africa" in Rutton, V.W. and C.E. Proy, (eds), Policy for Agricultural Research, West View Special Studies in Agricultural Science and Policy.

Eboh, E.C., I.N. Obasi & M.I. Uguru, (1990). Land Use Pressure and Agricultural Intensification in Anambara State of Nigeria: Implications for Socioeconomic and agronomic sustainability of agricultural productivity, Unpublished research report submitted to Social Science Research Council, New York.

Lagemann, **J.**, (1977). Traditional African Farming Systems in Eastern Nigeria: An anlysis of reaction to increasing population pressure, Weltforum Verlag, Munchen.

Nigot-Adholla, S., P. Hazell, B. Slarel & F. Place, (1991). "Indigenous Land Right Systems in Sub-Saharan Africa: A Constraint on Productivity?", The World Bank Economic Review. Vol. 5, No. 1, January.

Moutappa, F., (1974). "Soil Aspects of Shifting Cultivation in Africa and the need for a common approach to soil and land resources evaluation", FAO Soils Bulletin, No. 24.

Platteau, J., (1988). The Food Crisis in Africa: A Comparative Structural Analysis, WIDER Working Paper Series, No. 44, April, WIDER Publications, Finland.

Ruthernberg. H., (1980). Farming Systems in the Tropics Clarendon Press. Oxford.

Webater C.C. & P.N. Wilson, (1980). Agriculture in the Tropics Longman London. □

A leader in the true sense is one whom the followers grant the right to dictate.

— Edgar H. Schein

Technology Evaluation & Selection

Technology evaluation deals with whetting of various technology options. It is mainly used to select that technology which is most appropriate to one's need. The other objectives of technology evaluation could be to determine the feasibility of a given technology for industrial or other projects; to compare an existing technology with the state-of-art technologies to assess the scope for improvement/determine the technological strategies to catch up with the rest. It could also be for determining appropriate technology for a given socio-economic situation.

While technology evaluation gives a holistic view of various technology options available, technology selection deals with selecting one of these options. Here the decision is influenced by many extranious factors like availability of funds, market condition, scale of operation, scope of technology transfer, raw material and government policies etc. Proper evaluation and selection of technology will play a vital role therefore in realising growth objective.

NPC's Studies in Technology Evaluation

In the last four years NPC has carried out a number of studies on technology evaluation and developed norms for the Department of Science and Technology, for sectors like foundry, forging, electric lamps, glass and boiler industry. The objective of these studies has been to evaluate the status of technology in domestic industry vis-a-vis state-of-art technologies available abroad and suggest suitable measures to close the gap either through acquisition of technology from abroad or through indigenous R & D efforts.

Knowing State-of-Art

In NPC technology studies, the first phase is identification of technology sources, the characteristics of each technology, state-of-art etc. For this purpose extensive technology scanning is done for the product under study through publications, journals, seminar papers and interaction with domestic and foreign companies who are the leaders. Similarly, for the state-of-art, various patent information sources are contacted to get information. Information is also collected through, visiting trade fairs, user units, R & D bodies etc. Compilation of this information gives an idea of various technology options available.

Technology Status

The second phase comprises knowing the various technologies used for the product/industry under study within and outside the country. For this purpose, a suitable questionnaire is designed. This tries to elicit information on the following points.

- Plant capacity, Technology/Process used/Technology source, Quantitative assessment of product quality, Marketability, Production cost structure, Problems faced by the Units in adopting/absorption of given technology, Technology suitability to the local raw material, Product mix and upstream and downstream capacities, Level of automation, Technology absorption level

In addition, quantitative information pertaining to material usage, labour requirement, energy consumption, rejection level, safety, pollution level is also collected. The questionnaire is then circulated to predetermined units (based on sample size) in India and abroad. A few technology leader companies, R & D organisations and industry associations are personally visited by the consultants to have extensive interactions with their experts.

Evaluation Criteria

For technology evaluation, qualitative information is of little use as the same cannot be used for comparison. To overcome this limitation, important parameters are specifically identified which are quantifiable and reflect the efficiency of each process in terms of the following aspects:

- Scale of operation, Material productivity, Energy efficiency, Labour productivity, Reliability of process and maintainability of quality, Space utilisation, Degree of automation, Flexibility, Health and safety, Pollution level

Some important parameters to measure efficiency characteristics of any technology are given in table 1, for foundry industry. The data on these parameters from various units are collected. The values of each parameter will vary depending on the process/technology used by the unit. In order to evaluate each technology, a technology gradient scale is built. Table 2 gives one such scale used by NPC in evaluating technology. In this, each parameter is divided into five degrees with Degree 1 having least value to degree five the highest rate. Each parameter is assigned a weightage depending on the relative importance of one parameter over the other (for example material efficiency will receive highest weightage in material intensive industry while energy will be a high priority in energy intensive industry). The weightage for each point has to be decided by the expert group. In the example given in Table 2 a technology scale is built where values vary from 42 points cored to maximum 420 points. Depending on overall points the relative evaluation of technology can be done.

Table 1: Important Parameters for Technology Evaluation

Characteristics	Parameters	Example (For Foundry Industry)	Remarks
Capacity/Rate of production	Output in units/hour	Moulds/hour in case of casting industry	Gives an idea about scale of operation
Material production	Finished goods output/unit of material input	Yield (in casting industry) Tons of finished casting/ton of molten metal	Important parameter for material intensive industry like paint, electric lamps
Energy efficiency	Energy Consumed/Unit of production	KWH of energy consumed per ton of metal melted or per ton of finished casting produced	Gives idea of energy conservation possible (important in case of energy intensive industry like casting, forging)
Labour efficiency	Manpower employed/unit of production	Persons employed/ton production of finish casting	Gives idea about the labour intensity of given technology
Reliability of process	Rejection rate in percentage	Percent rejection in casting due to various casting defects	Gives indication how reliable is technology for producing items to specification consistently
Space utilisation	Space required/unit of finished production	Sq meters of area/of casting production	Parameter is important where space availability is a constraint
Degree of automation	No. of persons directly involved to run the plant	No. of persons required to the run moulding line for given number of moulding boxes investment made/person	This parameter overlaps with labour productivity parameter. Needs to be assessed by expert
Flexibility (Ability to produce other products with same setup)	No. of other products that can be produced	In case of furnace variation in raw material composition that can be melted in melting	Important factor when greater flexibility is required for product change over with minimum investment
Health & safety aspects	No. of accidents (Fatal/Non-fatal)	Accidents/number of man/year	Gives idea of process/technology from point of view of safety
Pollution hazard	Type of pollution caused. Pollution level in operation	Parts per million of pollutant	Very important parameter for pollution causing products. Ability to keep pollution level within prescribed limit of pollution control will be deciding factor for choosing technology
Overall efficiency of technology	Capacity utilisation	Utilisation of installed capacity	Measures the overall efficiency of process technology
Capital investment	Total investment in plant & machinery	Value	Gives idea of investment level required

Table 2: Technology Gradient Scale

Factor	Weigh-tage	Degree Definition and Point Value				
		Degree 1	Degree 2	Degree 3	Degree 4	Degree 5
Size/Capacity Rate of Production/ Speed & Feed	2	1 to 20% of the highest capacity plant	Above 20% to 50% of the highest capacity	Above 30% to 80%	Above 80% to 95% of the highest capacity plant	Above 95% to 100%
Material productivity	5	Below 60%	Above 60% to 80%	Above 80% to 90%	Above 90% to 97%	Above 79% Utilisation
		1 to 1.9	2 to 3.9	4 to 5.9	6 to 7.9	8 to 10
Energy efficiency	5	Below 30%	Above 30% to 60%	Above 60% to 75%	Above 75% to 90%	Above 90% to 100% of the highest obtained
		1 to 1.9	2 to 3.9	4 to 5.9	6 to 7.9	8 to 10
Labour productivity	4	Below 20% of the highest obtained	Above 20% to 50% of the highest obtained	Above 50% to 80% of the highest obtained	Above 80% to 95% of the highest obtained	95% to 100% of the highest obtained
		1 to 1.9	2 to 3.9	4 to 5.9	6 to 7.9	8 to 10
Instrumentation & Control/Degree of automation	4	No special tools instruments used for the various operations. All done by human effort and judgement	Mechanical—no automation, all material handling, inspection, operation done by operators	Partial automation, Materials handling automated; operations and inspection done by operators	Automated—all operations and materials handling automated and to some extent quality and condition monitoring also	Fully automated—(all operations, materials handling quality and condition monitoring, feedback and adjustment as well as supervision automated
		1 to 1.9	2 to 3.9	4 to 5.9	6 to 7.9	8 to 10
Flexibility	3	Completely rigid; can be used only for one model and one size of a product	Rigid, Can be used for one or two models with very small range of size	Flexible. Can be used for different sizes of the same product	Very flexible. Can be used only for different products and different sizes	Completely flexible. Many different types of products/operations can be done
		1 to 9	2 to 3.9	4 to 5.9	6 to 7.9	8 to 10
Overall efficiency/ Capacity utilisation	5	Below 50%	Above 50% to 75%	Above 75% to 85%	Above 85% to 95%	Above 95% of the highest
		1 to 9	2 to 3.9	4 to 5.9	6 to 7.9	8 to 10
Capital Output Ratio	5	Below 30%	Above 30% to 60%	Above 60% to 75%	Above 75% to 90%	Above 90% to 100% of the highest obtained
		1 to 9	2 to 3.9	4 to 5.9	6 to 7.9	8 to 10
Life Period	4	1 year and below	Above 1 year to 5 years	Above 5 years to 12 years	Above 12 years to 20 years	Above 20 years
		1 to 1.9	2 to 3.9	4 to 5.9	6 to 7.9	8 to 10

Technology Selection

After various technology options are evaluated the final selection can be made. Here many factors will influence the final selection like:

- Availability of technology from technology donar countries, Whether technology is proven (who are other users?), Whether required inputs are locally available and their suitability, Suitability of technology to market, Cost effectiveness of technology, Expected rate of return (ROI), Gestation period, In case of collaboration, nature and condition of technology transfer collaboration agreement technology cost performance guarantee, Government policies/trade restrictions

Each of the above factor again can be given weightage to arrive at the final selection.

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ndustrial Metabolism – Theory & Policy

Robert U. Ayres

The industrial metabolic system which is analogous to its biological counterpart has already equalled and outstripped the latter in terms of the rate of nutrient mobilization. The author analyses the recycling/reuse efficiency of the industrial system and recommends a holistic view to tackle the problem.

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The word metabolism, as used in its original biological context, connotes the internal processes of a living organism. The organism ingests energy rich, low entropy materials ('food'), to provide for its own maintenance and functions, as well as a surplus to permit growth and/or reproduction. The process also necessarily involves excretion or exhalation of waste outputs, consisting of degraded, high entropy materials. There is a compelling analogy between biological organisms and industrial activities – indeed, the whole economic system – not only because both are materials processing systems driven by a flow of free energy (Georgescu-Roegen, 1971), but because both are examples of self-organizing "dissipative systems" in a stable state, far from thermodynamic equilibrium (Ayres, 1988). At the most abstract level of description, then, the metabolism of industry is the whole integrated collection of physical processes that convert raw materials and energy, plus labour, into finished products and wastes in a (more or less) steady-state condition (Figure 1).

The production (supply) side, by itself, is not self-regulating. The stabilizing controls of the system are provided by its human component. This human role has two aspects: direct, as labour input, and indirect, as consumer of output (i.e., determinant of final demand). The system is stabilized, at least in its decentralized competitive market form, by balancing supply of and demand for both products and labour through the price mechanism. Thus, the economic system is, in essence, the metabolic regulatory mechanism. Industrial metabolism can be described as a number of levels below the broadest and most encompassing global one. Thus, the concept is obviously applicable to nations or regions, especially 'natural' ones such as watersheds or islands. The key to regional analysis is the existence of a well-defined geographical border or boundary across which physical flows of materials and energy can be monitored.

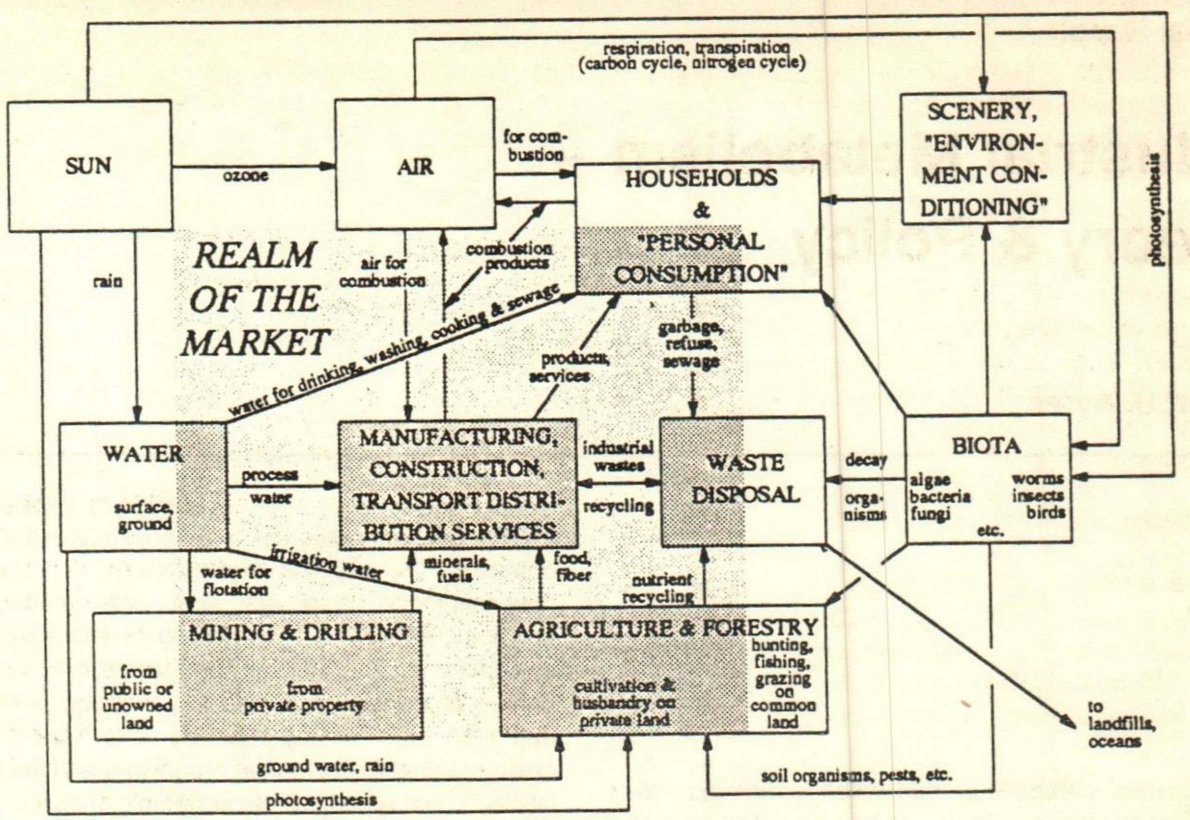

Fig. 1 The World of the Market

The concept of industrial metabolism is equally applicable to another kind of self-organizing entity, a manufacturing enterprise or firm. A firm is the economic analogy of a living organism in biology.[1] Some of the differences are interesting, however. In the first place, biological organisms reproduce themselves; firms produce products or services, not other firms (except by accident). In the second place, firms need not be specialized and can change from one product or business to another. By contrast, organisms are highly specialized and cannot change their behaviour expect over a long (evolutionary) time period. In fact, the firm (rather than the individual) is generally regarded as the standard unit of analysis in economics. The economic system as a whole is essentially a collection of firms, together with regulatory institutions and worker-consumers, using a common currency and governed by a common political structure. A manufacturing firm converts material inputs, including fuels or electric energy, into marketa… products and waste materials. It keeps financial accou… for all its external transactions; it is also relatively easy … track physical stocks and flows across the "boundary" … the firm and even between its divisions.

1 This analogy between firms and organisms can be carried further, resulting in the notion of "industrial ecology". Just as an ecosystem is a balanced, interdependent quasi-stable community of organisms living together, so its industrial analog may be described as a balanced, quasi-stable collection of interdependent firms belonging to the same economy. The interactions between organisms in an ecosystem range from predation and/or parasitism to various forms of cooperation and synergy. Much the same can be said firms in an economy.

The Materials Cycle

A third way in which the analogy between biologi… metabolism and industrial metabolism is useful is to foc… attention on the "life cycle" of individual "nutrients". T… hydrological cycle, the carbon cycle, and the nitrog… cycle are familiar concepts to earth scientists. The ma… way in which the industrial metabolic system differs fr… the natural metabolism of the earth is that the natu… cycles (of water, carbon/oxygen, nitrogen, sulfur, etc.) … closed, whereas industrial cycles are open. In ot… words, the industrial system does not generally recycle … nutrients. Rather, the industrial system starts with hi… quality materials (fossil fuels, ore) extracted from … earth, and returns them to nature in degraded form. T… point particularly deserves clarification. The materi… cycle, in general, can be visualized in terms of a system … compartments containing stocks of one or m… nutrients, linked by certain flows. For instance, in the c… of the hydrological cycle, the glaciers, the oceans,

·h water lakes and the groundwater are stocks while ıfall and rivers are flows. A system is closed if there are external sources or sinks. In this sense, the earth as a ɔle is essentially a closed system, except for the oc-·ional meteorite.

The major way in which the industrial metabolic system differs from the natural metabolism is that the natural cycles are closed, whereas industrial cycles are open. In other words, the industrial system does not generally recycle its nutrients.

A closed system becomes a closed cycle if the sys-m is also in steady state, i.e., the stocks in each com-·rtment are constant and unchanging, at least on the ·erage. The materials balance condition implies that the ·aterial inputs to each compartment must be exactly 'anced (on the average) by the outputs. If this condi-.n is not met, for a given compartment, then the stock in one or more compartments must be increasing, while the stocks in one or more other compartments must be decreasing.[2] A closed cycle of flows, in the above sense, can only be sustained indefinitely by a continuous flow of free energy. This follows immediately from the second law of thermodynamics, which states that global entropy increases in every irreversible process. Thus, a closed cycle of flows can be sustained as long as its external energy supply lasts. An open system, on the contrary, is inherently unstable and unsustainable. It must either stabilize or collapse to a thermal equilibrium state in which all flows, i.e, all physical and biological processes, cease.

It is sometimes convenient to define a generalized 4-box model to describe materials flows. The biological version is shown in Figure 2, while the analogous industrial version is shown in Figure 3. Reverting to the point made at the beginning, the natural system is characterized by closed cycles, at least for the major nutrients (carbon, oxygen, nitrogen, sulfur) – in which biological processes play a major role in closing the cycle. By contrast, the industrial system is an open one in which "nutrients" are transformed into "wastes," but not sig-

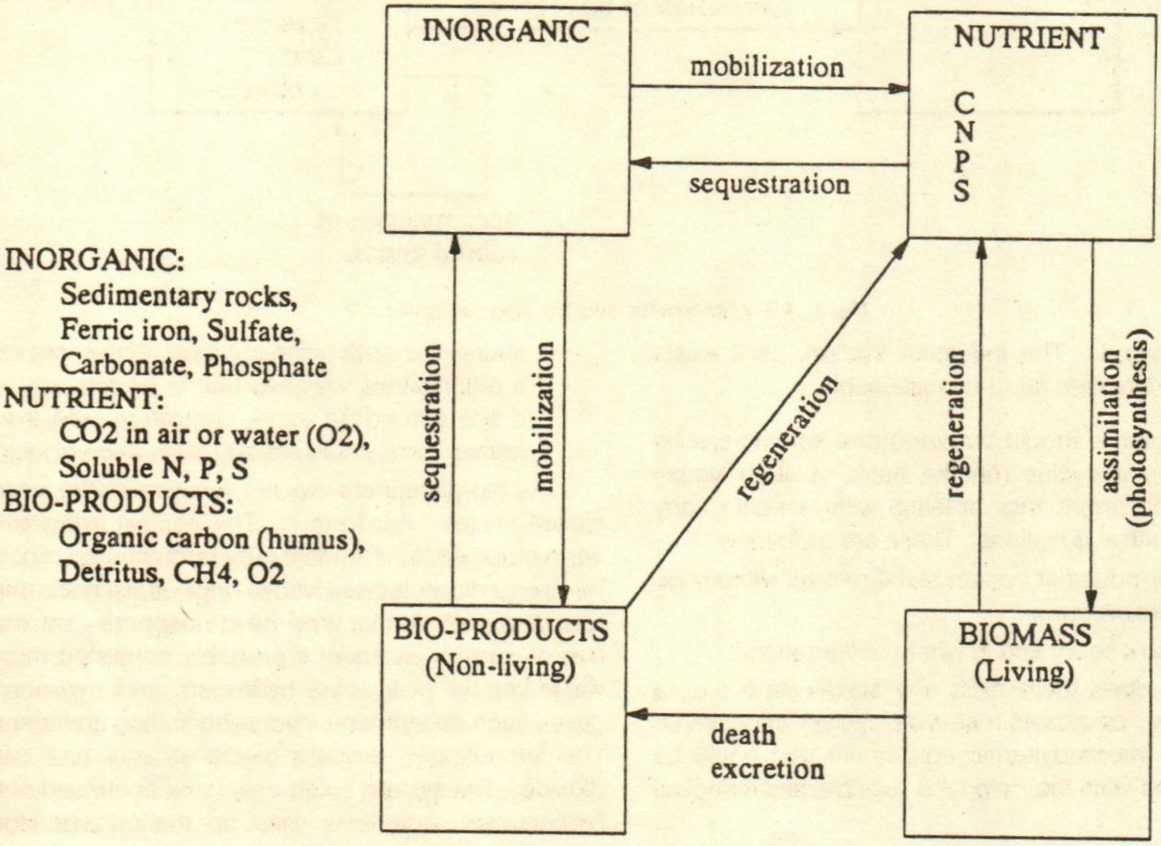

Fig. 2. 4-Box Scheme for Bio-Geo-Chemical Cycles

2 A moment's thought should convince the reader that if the stock in any compartment changes, the stock in at least one other compartment must also change.

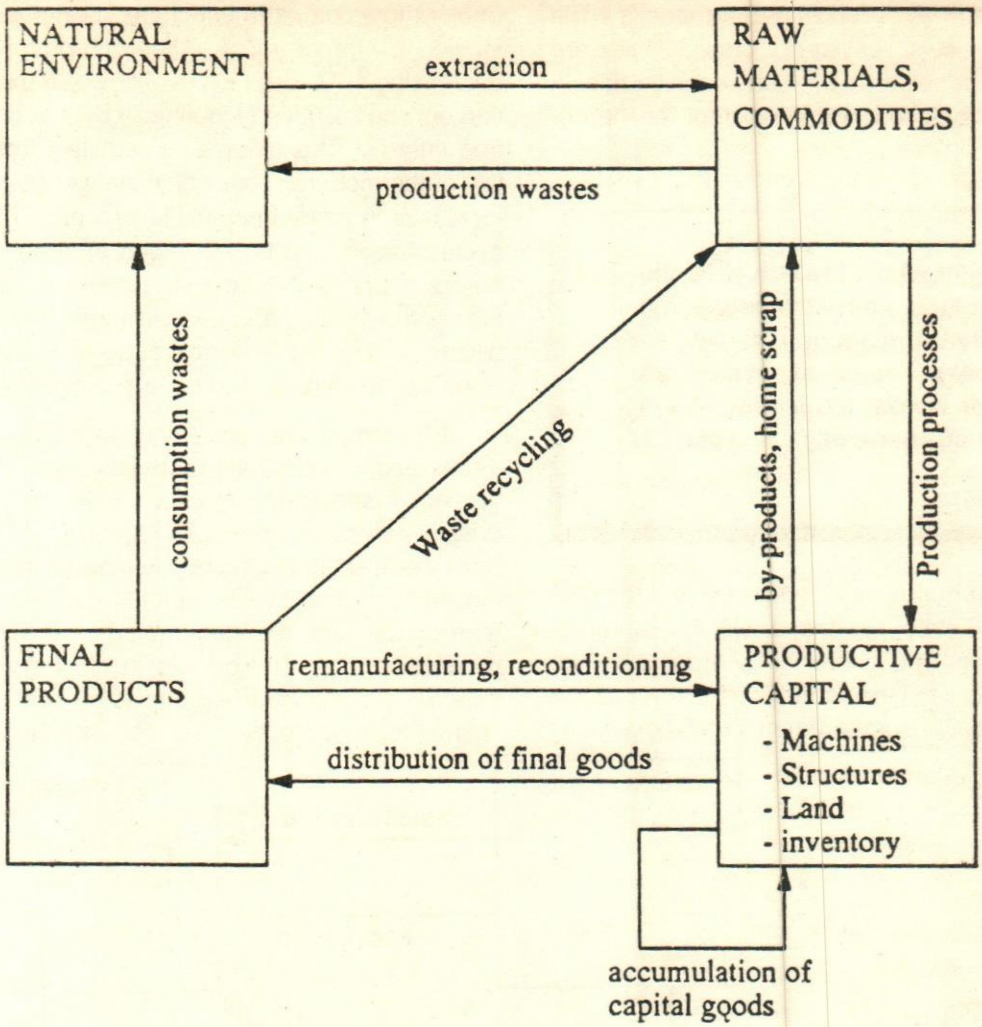

Fig. 3: 4-Box Scheme for Industrial Material Cycles

nificantly recycled. The industrial system, as it exists today, if therefore *ispo facto* unsustainable.

At this stage, it should be noted that nothing can be said about open cycles (on the basis of such simply thermodynamic arguments, at least) with respect to any of the really critical questions. These are as follows:

- Will the industrial system stabilize itself without external interference?
- If so, how soon, and in what configuration?
- If not, does there exist any stable state (i.e., a system of closed materials cycles) short of ultimate thermodynamic equilibrium that could be reached with the help of a feasible technological "fix"?
- If so, what is the nature of the fix, and how costly will it be?
- If not, how much time do we have until the irreversible collapse of the bio-geosphere system makes the earth uninhabitable? (If the time scale is a billion years, we need not to be too concerned. If it is a hundred years, civilization, and even the human race, could already be in deep trouble.)

The bio-geosphere was not always a stable system of closed cycles. Far from it. The earliest living cells on earth obtained their nutrients, by fermentation, from non-living organic molecules whose origin is still not completely understood. At that time the atmosphere contained no free oxygen or nitrogen; it probably consisted mostly of water vapour plus some hydrogen, and hydrogen-rich gases such as methane, hydrogen sulfide and ammonia. The fermentation process yields ethanol and carbon-dioxide. The system could only have continued until the fermentation organisms used up the original stock of "food" molecules or choked on the carbon-dioxide build-up. The system stabilized temporarily when a new organism (blue-green algae or cyano-bacteria) appeared that was capable of recycling carbon-dioxide into sugars and cellulose, thus again closing the carbon cycle. This new process was anaerobic photosynthesis.

However, the photosynthesis process also had a waste product: namely, oxygen. For a long time (over a billion years) the oxygen generated by anaerobic photosynthesis was captured by dissolved ferrous iron molecules, and sequestered as insoluble ferric oxide or magnetic, with the help of another primitive organism, the stromatolites. The resulting insoluble iron oxide was precipitated on the ocean bottoms.[3] (The result is the large deposits of high-grade iron ore we exploit today.) The system was still unstable at this point. It was only the evolutionary invention of two more biological processes, aerobic respiration and aerobic photosynthesis, that closed the oxygen cycle as well. Still other biological processes – nitrification and denitrification, for instance – had to appear to close the nitrogen cycle and others. Evidently, biological evolution responded to inherently unstable situations (open cycles) by "inventing" new processes (organisms) to stabilize the system by closing the cycles. This self-organizing capability is the essence of what has been called *Gaia*. However, the instabilities in question were slow to develop, and the evolutionary responses were also slow to evolve. It took several billion years before the biosphere reached its present degree of stability.

In the case of the industrial system, the time scales have been drastically shortened. Human activity already dominates and excels natural processes in many respects. While cumulative anthropogenic changes to most natural nutrient stocks still remain fairly small, in most cases[4], the rate of nutrient mobilization by human industrial activity is already comparable to the natural rate in many cases. Table 1 shows the natural and anthropogenic mobilization (flow) rates for the four major biological nutrients, carbon, nitrogen, phosphorus and sulfur. In all cases, with the possible exception of nitrogen, the anthropogenic contributions exceed the natural flows by a considerable margin. The same is true for most of the toxic heavy metals, as shown in Table 2.

Based on relatively crude materials-cycle analyses, at least, it would appear that industrialization has already drastically disturbed, and *ipso facto* destabilized, the natural system.

Measures of Industrial Metabolism

There are only two possible long-run fates for waste materials: recycling and reuse or dissipative loss.[5] (This is a straightforward implication of the law of conservation of mass). The more materials are recycled, the less will be dissipated into the environment, and *vice versa*. Dissipa-

Table 1: Anthropogenic Nutrient Fluxes (teragrams/years)

	Carbon		Nitrogen		Sulfur		Phosphorus	
	T/yr	%	T/yr	%	T/yr	%	T/yr	%
To Atmosphere, Total	7,900	4%	55.0	12.5%	93	65.5%	1.5	12.5%
Fossil fuel combustion & smelting	6,400		45.0		92			
Land clearing, deforestation	1,500		2.6		1		1.5	
Fertilizer volatilization[(a)]			7.5					
To Soil, Total			112.5	21%	73.3	23.4%	15	7.4%
Fertilization			67.5		4.0		15	
Waste disposal[(b)]			5.0		21.0			
Anthropogenic acid deposition			30.0		48.3			
Anthropogenic, (NH_3, NH_4) deposition			10.0					
To Rivers & Oceans, Total			72.5	25%	52.5	21%	5	10.3%
Anthoropogenic acid deposition			55.0		22.5			
Waste disposal			17.5		30.0		5	

(a) Assuming 10% loss of synthetic ammonia-based fertilizers applied to land surface (75 tg/yr).
(b) Total production (= use) less fertilizers use, allocated to landfill. The remainder is assumed to be disposed of via waterways.

3 Another kind of primitive marine organism apparently utilized hydrogen sulfide as an energy source. The sulfur, released as a waste, combined with the dissolved iron and precipitated out as iron sulfide (pyrites).

4 However, this statement is not true for greenhouse gases in the atmosphere. Already, the concentration of carbon-dioxide has increased 20 per cent since pre-industrial times, while the concentration of methane is up by 50 per cent. The most potent greenhouse gases, CFCs, do not exist in nature at all.

5 The special case of indefinite storage in dep underground mines, wells, or caverns, currently being considered for nuclear wastes, is not really applicable to industrial or consumer wastes except in very special and rare circumstances. Surface landfills no matter how well designed, are hardly permanent repositories although little consideration has been given to the long-run disposal of leachates.

Table 2. Worldwide Atmospheric Emissions of Trace Metals (1,000 tons per year)

Element	Energy Production	Smelting, Refining & Manufacturing	Manufacturing Processes	Commercial Uses, Waste Incineration & Transportation	Total Anthropogenic Contributions	Total Contributions by Natural Activities
Antimony	1.3	1.5	—	0.7	3.5	2.6
Arsenic	2.2	12.4	2.0	2.3	19.0	12.0
Cadmium	0.8	5.4	0.6	0.8	7.6	1.4
Chromium	12.7	—	17.0	0.8	31.0	43.0
Copper	8.0	23.6	2.0	1.6	35.0	6.1
Lead	12.7	49.1	15.7	254.9	332.0	28.0
Manganese	12.1	3.2	14.7	8.3	38.0	12.0
Mercury	2.3	0.1	—	1.2	3.6	317.0
Nicel	42.0	4.8	4.5	0.4	52.0	2.5
Selenium	3.9	2.3	—	0.1	6.3	3.0
Thalium	1.1	—	4.0	—	5.1	29.0
Tin	3.3	1.1	—	0.8	5.1	10.0
Vanadium	84.0	0.1	0.7	1.2	86.0	28.0
Zinc	16.8	72.5	33.4	9.2	132.0	45.0

Source: [Nriagu et al, 1990]

tive losses must be made up by replacement from virgin sources. A strong implication of this analysis is that a long-term (sustainable) steady-state industrial economy would necessarily be characterized by near-total recycling of intrinsically toxic or hazardous materials, as well as a significant degree of recycling of plastics, paper and other materials whose disposal constitutes an environmental problem. Admittedly, it is not possible to identify in advance all potentially hazardous materials, and it is quite likely that there will be (unpleasant) surprises from time to time. However, it is safe to say that heavy metals are among the materials that would have to be almost totally recycled to satisfy the sustainability criterion. The fraction of current metal supply needed to replace dissipative losses (i.e., production from virgin ores needed to maintain a stable level of consumption) is thus a useful, if partial, surrogate measure of "distance" from a steady-state condition, i.e., a condition of long-run sustainability.

There are only two possible long-run fates for waste materials: recylcing and reuse or dissipative loss. The more materials are recycled, the less will be dissipated into the environment, and *vice versa*.

However, a sustainable steady state is less a question of resource availability than of *recycling/reuse* efficiency. As commented earlier, a good measure of unsustainability is dissipative usage. This raises the distinction between *inherently dissipative* uses and uses where the material could be recycled or reused, in principle, but is not. The latter could be termed *potentially recyclable*. Thus, there are really three important cases:

- Uses that are economically and technologically compatible with recycling under present prices and regulations.
- Uses that are not economically compatible with recycling but where recycling is technically feasible, e.g., if the collection problems were solved and
- Uses where recycling is inherently not feasible.

From the standpoint of elements, if one traces the uses of materials from source to final sink, virtually all sulfur mined (or recovered from oil, gas or metallurgical refineries) is ultimately dissipated in use (e.g., as fertilizers or pigments) or discarded, as waste acid or as ferric or calcium sulfides or sulfates. (Some of these sulfate wastes are classes as hazardous.) Sulfur is mostly (75-80%) used to produce sulfuric acid, which in turn is used for many purposes. But in every chemical reaction, the sulfur must be accounted for – it must go somewhere. The laws of chemistry guarantee that reactions will tend to continue either until the most stable possible compound is formed or until an insoluble solid is formed. If the sulfur is not embodied in a "useful" product, it must end up in a waste stream.

There is only one long-lived structural material embodying sulfur; plaster-of-Paris (hydrated calcium sulfate) which is normally made directly from the natural mineral gypsum. In recent years, sulfur recovered from coal-burning power plants in Germany has been converted into synthetic gypsum and used for construction. However, this potential recycling loop is currently inhibited by the very low price of natural gypsum. Apart from synthetic gypsum, there are no other durable materials in which sulfur is physically embodies. It follows from materials balance considerations that sulfur is entirely dissipated into the environment. Globally, about 61.5 million metric tons of sulfur qua sulfur – not including gypsum – was produced in 1988. Of this, less than 2 million was recycled (mainly as waste sulfuric acid), as indicated schematically in Figure 4. Very little is currently used for structural materials. Thus, most sulfur chemicals belong in class 3.

Following similar logic, it is easy to see that the same is true of most chemicals derived from ammonia (fertilizers, explosives, acrylic fibers) and phosphorus (fertilizers, pesticides, detergents, fire retardants). In the case of chlorine, there is a division between class 2 (solvents, plastics, etc.) and class 3 (hydrochloric acid, chlorine used in water treatment, etc.). Chlorofluorocarbon refrigerants and solvents are long-lived and non-reactive. In fact, this is the reason they pose an environmental hazard. Given an appropriate system for recovering and reconditioning old refrigerators and air-conditioners, the bulk of the refrigerants now in use could be recovered, either for reuse or destruction. Hence, they belong in class 2. However, CFCs used for foam-blowing are not recoverable. Table 3 shows the world output of a number of materials – mostly chemicals – whose uses are, for the most part, inherently dissipative (class 3). it would be possible, with some research, to devise measures of the inherently dissipative uses of each element, along the lines sketched above. Sustainability, in the long run, would imply that such measures decline. Currently, they are almost certainly increasing.

With regard to materials that are potentially recyclable (classes 1 and 2), the fraction actually recycled is a useful measure of the approach toward (or away from) sustainability. A reasonable proxy for this, in the case of metals, is the ratio of secondary supply to the total supply to final materials; see, for example, Table 4. This table shows, incidentally, that the recycling ratio in the United States has been rising consistently in recent years only for

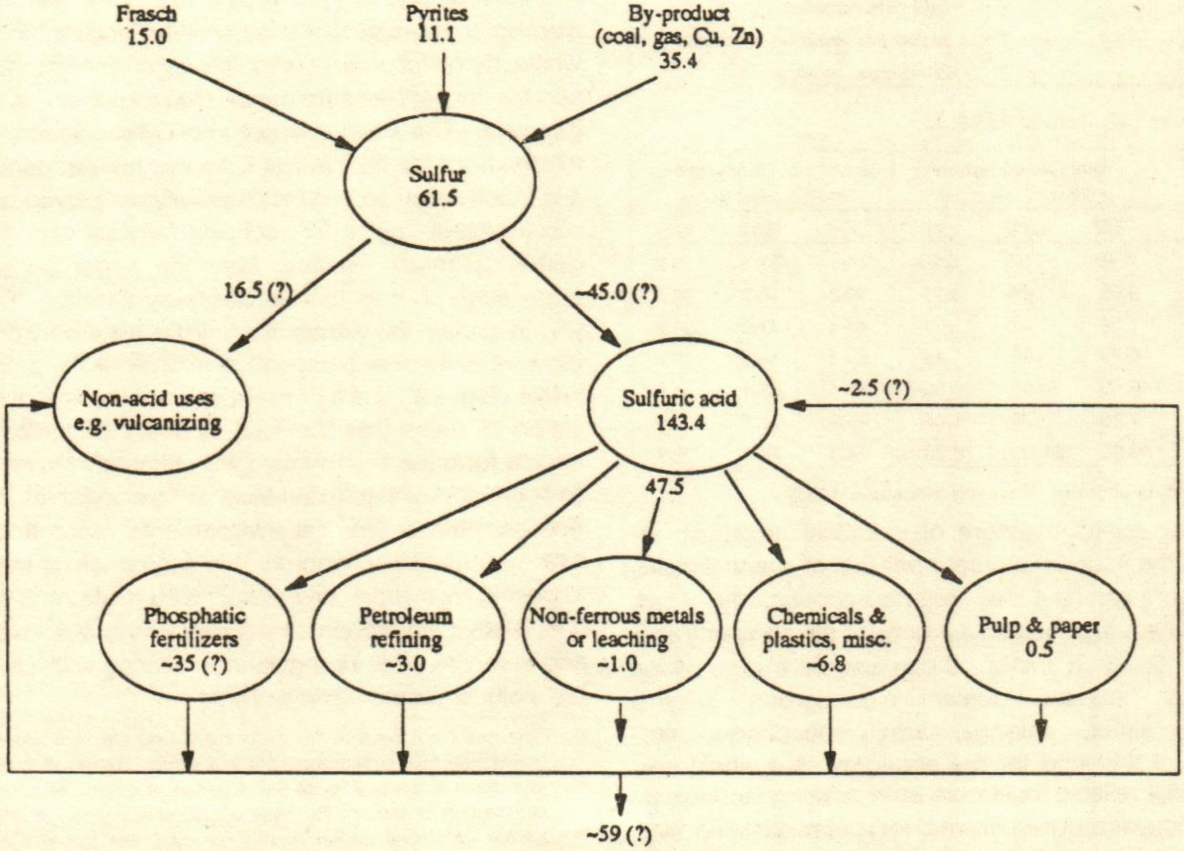

Fig. 4: Dissipative Uses of Sulfur 1988 (millions of metric tons)

lead and iron/steel. In the case of lead, the ban on using tetraethyl lead as a gasoline additive (an inherently dissipative use) is entirely responsible.

Table 3. Examples of Dissipative Use (Global)

Substance	10^6 T	Dissipative Uses
Other Chemicals		
Chlorine	25.9	Acid, bleach, water treatment, (pvc) solvents, pesticides, refrigerants
Sulfur	61.5	Acid (H_2SO_4) bleach, chemicals, fertilizers rubber
Ammonia	24.0	Fertilizers, detergents, chemicals
Phosphoric Acid	93.6	Fertilizers, nitric acid, chemicals, (nylon, acrylics)
NaOH	35.8	Bleach, soap, chemicals
Na_2CO_3	29.9	Chemicals (glass)
Heavy Metals		
Copper Sulfate ($CuSO_4$ $5H_2O$)	0.10	Fungicide, algicide, wood preservative, catalyst
Sodium bichromate	0.26	Chromic acid (for plating), tanning, algicide
Lead Oxides	0.24	Pigment (glass)
Lithopone (ZuS)	0.46	Pigment
Zinc Oxides	0.42	Pigment (tires)
Titanium Oxide (TiO_2)	1.90	Pigment
TEL	?	Gasoline additive
Arsenic	?	Wood preservative, herbicide
Mercury	?	Fungicide, catalyst

Table 4. Scrap Use in the United States

	Total Consumption (million short tons)			% of Total Consumption in Recycled Scrap		
Material	1977	1982	1987	1977	1982	1987
Aluminum	6.49	5.94	6.90	24.1	33.3	29.6
Copper	2.95	2.64	3.15	39.2	48.0	39.9
Lead	1.58	1.22	1.27	44.4	47.0	54.6
Nickel	0.75	0.89	1.42	55.9	45.4	45.4
Iron/Steel	142.40	84.00	99.50	29.4	33.4	46.5
Zinc	1.10	0.78	1.05	20.9	24.1	17.7
Paper	60.00	61.00	76.20	24.3	24.5	25.8

Source: [Institute of Scrap Recycling Industries, 1988]

Another useful measure of industrial metabolic efficiency is the economic output per unit of material input. This measure can be called *materials productivity*. It can be determined, in principle, not only for the economy as a whole, but for each sector. It can also be measured for each major "nutrient" element, e.g., carbon, oxygen, hydrogen, sulfur, chlorine, iron, phosphorus, etc. Measures of this kind for the economy as a whole are, however, not reliable indicators of increasing technological efficiency, or progress toward long-term sustainability. The reason is that increasing efficiency-especially in rapidly developing countries – can be masked by structural, changes, such as investment in heavy industry, which tend to increase the materials (and energy) intensiveness of economic activity. On the other hand, within a given sector, one would expect the efficiency of materials utilization – or materials productivity – to increase, in general.[6]

Useful aggregate measures of the state of the environment *vis-a-vis* sustainability can be constructed from physical data that are already collected and compiled in many countries. To derive these aggregates and publish them regularly would provide policy-makers with a valuable set of indicators at little cost. Other interesting and useful measures based on physical data are also possible. Moreover, if similar data were collected and published at the sectoral level, it would be possible to undertake more ambitious engineering-economic systems analyses and forecasts – of the kind currently possible only for energy – in the entire domain of industrial metabolism.

Policy Implications

It may seem odd to suggest that a mere viewpoint – in contradistinction to empirical analysis – may have policy implications. But it is perfectly possible. In fact, there are two implications that come to mind. First, the industrial metabolism perspective is essentially "holistic" in that the whole range of interactions between energy, materials and the environment are considered together – at least, in principle. The second major implication, which virtually follows from the first, is that from this holistic perspective it is much easier to see that narrowly conceived or short-run (myopic) "quick fix" policies may be very far from global optimum. In fact, from the larger perspective, many such policies can be positively harmful. The best way to explain the virtues of a holistic view is by contrasting it with narrower perspective. Consider the problem of waste disposal. It is a consequence of the law of conservation of mass that the total quantity of materials extracted form the environment will ultimately return thence as some sort of waste residuals or "garbo-junk" (Ayres & Kneese, 1969, p. 89). Yet environmental protection policy has systematically ignored this fundamental reality by imposing regulations on emissions by medium. Typically, a legislative act mandates a bureaucracy that formulates and enforces a set of regulations dealing with emissions by "point sources." And so forth.

6 This need not be true for each individual element, however. A major materials substitution within a sector can result in the use of one material increasing, at the expense of others, of course. The substitution of plastics for many structural materials, or of synthetic rubber for natural rubber, would exemplify this sort of substitution. Currently, glass fibers are in the process of substituting for copper wire as the major carrier of telephonic communications, for instance.

Not surprisingly, one of the things that happened as a result was that some air pollution (e.g., fly ash and SO_X from fossil fuel combustion) was eliminated by converting it to another form of waste, such as a sludge to be disposed of on land. Similarly, some forms of waterborne wastes are captured and converted to sludges for land disposal (or, even, for incineration). Air and water pollution were reduced, but largely by resorting to land disposal. But landfills also cause water pollution (leachate) and air pollution, due to anaerobic decay processes.

In short, narrowly conceived environmental policies over the past twenty years and more have largely shifted waste emissions from one form (and medium) to another, without significantly reducing the totals. In some cases, policy has encouraged changes that merely dilute the waste stream without touching its volume at all. The use of high stacks for coal burning power plants and the building of longer sewage pipes to carry wastes further offshore exemplify this approach. To be sure, these shifts may have been beneficial in the aggregate. But the costs have been quite high, and it is only too obvious that the state of the environment "in the large" is still deteriorating rapidly. One is tempted to think a more holistic approach, from the beginning, might have achieved considerably more at considerably less cost.

In fact, there is a tendency for suboptimal choices to get "locked in" by widespread adoption. Large investments in so-called "clean-coal" technology would surely extend the use of coal as a fuel—and eventuality highly desired by the energy establishment—but would also guarantee that larger cumulative quantities of sulfur, fly ash (with associated toxic heavy metals) and carbon-dioxide would be produced. The adoption of catalytic convertors for automative engine exhaust is another case in point. This technology is surely not the final answer, particularly since it is not effective in older vehicles. Yet it has deferred the day when internal combustion engines will eventually be replaced by some inherently cleaner automative propulsion technology. By the time that day comes, the world's automotive fleet will be two or three times bigger than it might have been otherwise, and the cost of substitution will be enormously greater.

Narrowly conceived environmental policies over the past twenty years and more have largely shifted waste emissions from one form (and medium) to another, without significantly reducing the totals.

The implication of all these points for policy-makers, of course, is that the traditional governmental division of responsibility into a great number of independent bureaucratic fiefdoms is dangerously faulty.[7] But the way out of this organizational impasse is far from clear. Top down central planning has failed miserably, and is unlikely to be tried again. On the other hand, pure "market" solutions to environmental problems are limited in cases where there is no convenient mechanism for valuation of environmental resources assets (such as beautiful scenery) or functions (such as UV protection afforded by the stratospheric ozone layer). This is primarily a problem of *indivisibility*. Indivisibility means that there is no possibility of subdividing the attribute into "parcels" suitable for physical exchange. In some cases this problem can be finessed by creating exchangeable "rights" or "permits," but the creation of a market for such instruments depends on other factors, including the existence of an effective mechanism for allocating such rights, limiting their number, and preventing poaching or illicit use of the resource. Needless to say, the policy problems have economic and socio-political ramifications well beyond the scope of this paper. However, as the Chinese proverb has it, the longest journey begins with a single step.

References

Ayres, Robert, U. (1988). "Self-organisation in biology and economics." International Journal on the Unity of the Sciences 1 (3)

Ayres, Robert, U. & Allan V. Kneese (1969). "Production, consumption and externalities." American Economics Review, June

Ayres, Robert U. & Allan V. Kneese (1989). "Externalities: economics and thermodynamics". In F. Archibugi and P. Nijkamp (eds), Economy and Ecology: Towards Sustainable Development, Kluwer Academic Publishers, Dordrecht

Georgescu-Roegen, Nicholas (1971). The Entropy Law and the Economic Process. Cambridge, MA: Harvard University Press

Nriagu, J.O. (1990),, "Global metal pollution". Environment 32 (7): 7-32

Rogner, Hans-Holger (1987). "Energy in the world: The present situation and future options." In Proceedings of the 17th International Congress of Refrigeration, August 24-28 □

7 The analogous problem is beginning to be recognized in the private sector, as the legacy of Frederick Taylor is finally being challenged by new managerial/organisational forms. Taylorism has been criticized extensively, but its major problem arises from two (explicit) assumptions that the firms' activities can be subdividing work into individual tasks, each of which can be performed independently of all others, and that maximizing output at the task level will maximize output (or profit) for the firm as a whole. The large US firms, which adopted Taylorism first and most enthusiastically at the beginning of the twentieth century, have been the slowest to adapt themselves to the new situation of intense international competition and faster technological change.

Bicycle Industry in India : Implications for Urban Development

R.S. Tiwari

Transportation plays a vital role in the economy and can be considered to be the barometer of a country's industrial development. In the context of spiralling petrol rates and the increasing environmental degradation due to motorised modes of transport, the author advocates the use of bicycles for local transport.

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The role of transportation in the process of economic development hardly needs any elaboration. Historically, transport has been recognised as a cause, an accompaniment and an indicator of a country's economic development, though different modes of transport have differential impact under different situations at different space points. Transport network "increases the accessibility to productive resources and physical mobility of raw materials, finished products and factors of production; promotes competition and hence economic efficiency; and creates conditicns for increasing the scale of production, on the one hand, and for strengthening of economic linkages on the other. Another way in which transport can influence the process of growth is through changes in attitudes and behaviour of the people facilitating the dispersal of knowledge and réduction in socio-cultural bottlenecks – the taboos and traditions – which tend to inhibit the adoption of modern technologies, and the growth and diversification of demand for final goods and services." (Papola & Sinha, 1981; 1-2)

Transport network "increases accessibility to productive resources and physical mobility of production; promotes competition and economic efficiency, increasing the scale of production and strengthening economic linkages.

In most developing economies, a discriminatory but selective transport policy had been pursued. The fuel-intensive motorised mode of transport had been encouraged through various incentives and subsidies, whereas, energy-efficient informal mode of transport had been discouraged. Such a development strategy not only resulted in environmental degradation but also inflated the import bill for the purchase of petrol, which, in turn, created serious balance of payment crisis. Therefore, developing countries should reorient their transport policy in a way that should not only be energy efficient but also be able to meet the increasing transport need of poor urban dwellers. Here, the traditional mode of transport assumes importance (Replogle, 1991).

Among the traditional modes of transport in Asian countries, the bicycle has been recognised as a predominant means of short-distance vehicular transport. In China, over 160 million bicycles, exist and over 50 per cent of vehicular-passenger movements are by bicycles. Similar is the case with Thailand, Indonesia, India and several other developing countries, where the use of bicycle for short-distance movement is a common phenomenon. (Pendkur, 1991). In metropolitan and small and medium sized cities too, the use of bicycle is very common, which is largely due to rapid urbanisation, spurt in rural to urban migration, hike in petrol prices and the existing levels of poverty of urban dwellers. Urban communities at large now not only find it difficult to buy their vehicle but also to pay the fare of public transportation.

Determination of Domestic Demand

Determination of home demand for a commodity is a very complex problem. Empirical treatment incorporating the income and price as determining variables for demand under theoretical framework is no longer considered sufficient and, factors determining the nature of human behaviour are recognised as more important and realistic. The problem of demand estimation becomes more complex if commodities are classified as 'durables' as distinct from 'non-durables'. Durability is a relative concept. If a product exhausts its utility at one point of time, it is called non-durable, whereas, it is durable if utility or satisfaction derived from that product is continuous over a period of time. Therefore, the nature of the product determines the demand.

Under normal circumstances, demand for a commodity is a function of income and relative price. This is, however, not the whole truth in the context of bicycle, in which case the demand is largely influenced by an increase in petrol prices, implying thereby the impact of cross elasticity of demand on demand determining model. An increase in the price of petrol is likely to cut down the internal demand for petrol consuming vehicles, which, in turn, is likely to stimulate the demand for petrol – saving vehicles. A practical approach thus calls for the inclusion of petrol price along with income and price variables in the demand deterministic model.

So far, no single variable had been evolved, which could serve as an appropriate proxy variable for domestic demand. Various researchers guided by their own intuitions and data limitations used different proxy variables for domestic demand, such as, deviations of industrial production to its trend value and unemployment rate (Ball et al 1966), indices of physical output of the exporting country as a ratio of rival's physical output indices, (Smith, 1958) ratio of actual value of industrial production (Henry, 1970), home sales (Cooper & Hartley, 1970) total consumption minus export (Ahmed, 1976), total output plus import (National Council of Applied and Economic Research, 1971) and total output plus import minus export (Tiwari, 1986).

Though each of these proxy variables captures the major dimension of the domestic demand, all suffer from an important drawback. All, excepting total output plus import minus export, did not make a distinction between durables and non-durables and hence determined domestic demand for all commodities uniformly. It would, however, have been useful and ideal to test as to what proxy variable would be the most suitable for domestic demand. Since our purpose is narrowly focussed on determining the domestic demand, it was not attempted in this exercise. Instead, we have determined the domestic demand separately for 'durable' as distinct from 'non-durable.' For a durable commodity like bicycles, total output plus import has been used as proxy variable for domestic demand, which, under the durability assumption of 30 years, has been worked out cumulatively. In the case of a non-durable commodity like bicycle tyres, total output plus import has been used as a proxy for domestic demand. However, the domestic demand for other components of bicycles has not been determined on account of data limitations. Hence, analysis on this count is only confined to the determination of domestic demand of bicycle tyres alone. The explanatory variables for domestic demand of bicycles include, personal disposable income, relative prices and the petrol prices, while for bicycle tyres only the first two have been used in the demand deterministic model. Total output plus import of bicycles and bicycle tyres has been used in thousand numbers, while personal disposable income and other related variables have been expressed in 1971 prices. Personal disposable income readily available at current prices has been converted at 1971 prices by applying the appropriate GDP deflator at the comparable base. Relative prices have been worked out by dividing separately the whole sale price of bicycles and tyres to the general whole sale price index at the comparable base which is expressed in percentage term. Similarly, price indices of petrol readily available have been converted at a comparable base. Data on personal disposable income, relative prices, prices of petrol and output have been collected from Indian Data Base : The Economy, (Annual Time Series Data) compiled and published by H.L. Chandhok and Policy Group, 1990 and from various issues of Economic Survey, 1991-92, Government of India, Ministry of Finance. Data on import of bicycles and tyres have been collected from various issues of Monthly Statistics of Foreign Trade of India, published by DGCI & S, Calcutta. Multiple regression models in linear and log-linear forms have been employed for the determination of internal demand, which is as follows:

Domestic Demand for Bicycles

- Linear Regression Model:

$$Y_1 = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + u \qquad (1)$$

- Log-Linear Regression Model:

$$\text{Log } Y_1 = a + b_1 \log x_1 + b_2 \log x_2 + b_3 \log x_3 + u \qquad (2)$$

Domestic Demand for Tyres

- Linear Regression Model:

$$T_1 = a + b_1 c_1 + b_2 c_2 + u \qquad (3)$$

- Log Linear Regression Model:

$$\text{Log } T_1 = a + b_1 \log c_1 + b_2 \log c_2 + u \qquad (4)$$

Results of the regression models are shown in tables 1 and 2. Values of regression coefficients and R2 are statistically significant in most of the cases, which show the goodness of fit of equations. The overall results of the statistically reliable models show that there is a strong and positive relationship between the demand for bicycles and the personal disposable income and the petrol prices, whereas, inverse relationship has been postulated between the dependent variable and the relative prices. For instance, over the period of 1951-52 to 1989-90, it is found from the log-linear models that 1 per cent increase of personal disposable income and petrol prices has resulted in an increase of home demand of bicycles by 5.71 per cent and 1.68 per cent respectively.

Demand for bicycles is found to be elastic with respect to all independent variables. Similarly, demand for bicycle tyres is found to be positively associated with personal disposable income; whereas, a strong but in-

Table 1: Determination of Domestic Demand of Bicycles in India Over Years

Period	Constant term (a)	Regression Coefficient of personal disposable income (x_1)	Regression Coefficient of relative prices (x_2)	Regression Coefficient of petrol prices (x_3)	R^2 = Value	F = Statistics	D.W. = Values
		A. Linear Regression Model: $Y_1 = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + u$					
1951-52–1969-70	– 14978.20	0.76* (6.51)	– 38.48** (– 2.35)	158.95* (3.06)	0.99*	495.00	0.98 (b)
1970-71 – 1989-90	– 6020.09	1.37* (7.61)	– 205.16* (– 3.42)	19.40 (1.48)	0.99*	528.00	2.30 (a)
1951-52 – 1989-90	– 9764.18	1.02* (11.62)	– 68.37* (– 5.04)	43.16* (6.84)	0.99*	1155.00	2.45 (a)
		B. Log-Linear Regression Model: $\text{Log } Y_1 = a + b_1 \log x_1 + b_2 \log x_2 + b_3 \log x_3 + u$					
1951-52 – 1969-70	– 94.36	9.23* (5.94)	– 2.40** (– 1.91)	– 0.45 (– 0.21)	0.94*	15.67	1.00 (b)
1970-71 – 1989-90	– 2.09	1.22* (10.82)	– 0.33* (– 3.49)	0.21* (3.70)	0.99*	528.00	2.48 (a)
1951-52 – 1989-90	– 30.89	5.71* (6.96)	– 2.28* (– 3.81)	1.68* (4.08)	0.89*	95.00	2.59 (a)

Note: Figures in parentheses denote 't values'

* Indicates significant at 1 per cent level

** Indicates significant at 5 per cent level

*** Indicates significant at 10 per cent level

(a) Implies absence of auto correlation

(b) Implies auto correlation to be inconclusive.

Basic Source: Chandhok, H.L. and Policy Group, 1990; *Economic Survey*, Various issues.

Table 2: Determination of Domestic Demand of Bicycle Tyres in India Over Years

Period	Constant terms (a)	Regression Coefficient of personal disposable income (c_1)	Regression Coefficient of relative prices (c_2)	R^2 = Value	F = Statistics	D.W. = Values
		A. Linear Regression Model: $T_1 = a + b_1 c_1 + b_2 c_2 + u$				
1951-52 – 1969-70	– 1191.77	1.13* (9.96)	– 92.59* (– 4.12)	0.99*	4.95.00	1.10 (b)
1970-71 – 1989-90	36943.34	0.16* (4.20)	– 214.69* (– 4.65)	0.99*	528.00	2.40 (a)
1951-52 – 1989-90	36321.36	0.16* (4.00	– 202.76* (– 10.73)	0.98*	571.67	2.52 (a)
		B. Log Linear Regression Model: $\text{Log } T_1 = a + b_1 \log c_1 + b_2 \log c_2 + u$				
1951-51 – 1969-70	– 18.31	2.90* (15.23)	– 0.32 (– 1.48)	0.97*	161.67	2.30 (a)
1970-71 – 1989-90	9.46	0.31* (4.58)	– 0.60* (– 4.40)	0.73*	14.42	1.69 (a)
1951-52 – 1989-90	7.67	0.67* (3.74)	– 1.05* (– 4.06)	0.83*	56.96	2.50 (a)

Note: Figures in parenthesis denote 't values'
* Indicates significant at 1 per cent level
(a) Implies absence of auto correlation
(b) Implies auto correlation to be inconclusive.
Basic Source: Chandhok, H.L. and Policy Group, 1990; *Economic Survey*, Various issues.

verse relationship personal disposable income has led to an increase in demand for bicycle tyres by 0.67 per cent, while an increase of 1 per cent in relative price has resulted in a fall of demand by 1.05 per cent. Thus, the internal demand for bicycle tyres is found to be inelastic with respect to income, but, elastic with relative prices (table 2).

Output Growth & Export

The internal demand for bicycles and its tyres determined by income, price and related variable also influences the level of production. The output of bicycles, which was 99 thousand numbers during 1951-52 shot upto 1063 in 1960-61, 2042 in 1970-71, 4189 in 1980-81, which by 1990-91 increased to 6879 thousands. Over 1951-52 to 1990-91, the output of bicycle recorded an increase by over 69 times. Similar was the case with bicycle tyres, which increased by over 6 times from 3941 thousand numbers in 1951-52 to 24800 thousand in 1990-91. Sizeable growth of metropolis owing to spurt in rural-urban migration, also influenced the output of bicycle and thereby its overall availability. Availability of bicycles per lakh of population, which was only 31 in 1951-52 increased to 242 in 1960-61, 387 in 1970-71, 564 in 1980-81 and which by 1990-91 reached at the peak level of 815. Over 1951-52 to 1990-91, it recorded an increase over 26 times (table 3).

Compared to international standards, the relative position of India has not been discouraging. Table 4 shows the relative position of principal bicycle producing countries of the world over 1976 and 1983. This part of analysis is, however, only indicative but it highlights the broad pattern about the position of bicycle production in the world. Table 4 shows that among the principal bicycle producing developing countries, the relative output share of bicycles increased only in China, India, Pakistan, Mexico and Maldives, whereas, in the rest of developing countries, it declined. Among the major bicycle producing developed countries, the relative share of bicycles only increased in Austria from 0.4 per cent in 1976 to 0.5 per cent in 1983, whereas, the respective share in the rest of the developed countries, except Sweden, fell down.

In Sweden the relative share of bicycle, however, stagnated at 0.4 per cent. For the developed countries as a whole, the relative share of bicycles fell down drastically from 55.3 per cent in 1976 to 36.6 per cent in 1983; in developing countries, it improved marginally from 18.2 per cent to 18.8 per cent; but in centrally planned economies, it improved considerably from 26.5 per cent to 44.6 per cent over the same time period (Work, 1991). When most of the developed and developing countries had been losing their relative output shares in bicycles, India and few developing countries were able to raise it by exploiting the potential existing in their internal economies. However, the improved share of bicycle output in the developing countries in general and India in particular, had not been sufficient to improve the relative

Table 3: Production of Bicycles Bicycle Tyres and Availability of Bicycles in India : 1951-52 — 1990-91

Year	Production of bicycles, (in '000 Nos.)	Production of bicycle tyres (in '000 Nos.)	Availability of bicycles per one lakh of population (Nos.)
1951-52	114	3941	31
1952-53	197	4190	53
1953-54	264	4645	70
1954-55	372	5226	96
1955-56	491	5748	125
1956-57	664	6319	166
1957-58	791	7152	193
1958-59	913	8259	218
1959-60	991	9511	233
1960-61	1050	10830	242
1961-62	1049	11346	236
1962-63	1116	11940	246
1963-64	1166	14186	251
1964-65	1420	16156	300
1965-66	1540	18132	318
1966-67	1631	19639	329
1967-68	1704	23338	337
1968-69	1952	24620	377
1969-70	1933	21611	365
1970-71	2094	20989	387
1971-72	1817	20663	328
1972-73	2287	21650	403
1973-74	2544	21768	439
1974-75	2483	25720	419
1975-76	2175	24530	358
1976-77	2643	23600	426
1977-78	3150	27000	497
1978-79	3400	31370	524
1979-80	3972	28840	598
1980-81	3830	27240	564
1981-82	5100	26570	735
1982-83	4870	27900	687
1983-84	5777	30075	798
1984-85	5890	32664	797
1985-86	5646	35100	749
1986-87	6119	33600	785
1987-88	6676	31600	840
1988-89	6703	26000	826
1989-90	6802	25600	822
1990-91	6879	24800	815

Basic Source: Chandhok, H.L. and Policy Group, 1990; *Economic Survey*, Various issues

Table 4: Production of Bicycle and Its Relative Share in the World (Qty. in '000 Nos. and Share in %)

Countries	1976		1983	
	Quantity	Percent	Quantity	Percent
China	6250	12.5	27580	35.0
Japan	6310	12.6	7039	8.9
United States	6400	12.8	6270	8.0
USSR	4354	8.7	6000	7.6
India	2643	5.3	5000	6.3
Germany, Fed. Rep.	3857	7.7	3921	5.0
Italy	2013	4.0	2400	3.0
Brazil	1545	3.1	2050	2.6
France	1942	3.9	1950	2.5
United Kingdom	1838	3.7	1550	2.0
Poland	1469	3.0	1300	1.6
Mexico	660	1.3	1270	1.6
Spain	752	1.5	964	1.2
Netherlands	976	2.0	934	1.1
Korea Rep.	562	1.1	731	0.9
Czechoslovakia	507	1.0	680	0.9
German Democratic Rep.	560	1.1	651	0.8
Maldives	296	0.6	625	0.8
Canada	466	0.9	N.A.	N.A.
Argentina	700	1.4	N.A.	N.A.
Sweden	195	0.4	300	0.4
Pakistan	218	0.4	442	0.6
Austria	214	0.4	399	0.5
Indonesia	260	0.5	350	0.4
Romania	240	0.5	N.A.	N.A.
Norway	185	0.4	N.A.	N.A.
Belgium	368	0.7	N.A.	N.A.
Total World Production of which:	52000	100.0	82000	100.0
Developed Market Economies	28768	55.3	30012	36.6
Developing Market Economies	9473	18.2	15413	18.8
Centrally Planned Economics	13759	26.5	36575	44.6

Source: United Nations, *Year Book of Industrial Statistics*, Various Issues.

share of export of bicycle in the total world bicycle export. The export share of bicycles in India, which was 2 per cent in world bicycle export in 1979, drastically fell down over time, which by 1980 remained at 0.1 per cent and by 1989 became a very negligible proportion.

Cost Structure & Technology

Since, India is merely a price taker in the world bicycle export, it is not possible to control the factors of external demand and hence attempt has to be made to improve the conditions on the internal supply front. The cost components of bicycle industry vis-a-vis the average of all Indian Industries over different points of time is examined in table 5. To produce one rupee worth of bicycle required Rs. 0.81 of material cost in 1975-76, Rs. 0.84 in 1977-78 and Rs. 0.89 in 1985-86 as compared to Rs. 0.77, Rs. 0.77 and Rs. 0.81 employed by the average of all industries. This implied that bicycle industry was more material cost intensive than the average for all industries. In sharp contrast to this, the bicycle industry was found to be relatively less capital intensive vis-a-via the average of all industries. To produce one rupee of bicycle, the requirement of productive capital was Rs. 0.27 in 1975-76, Rs. 0.23 in 1977-78 and Rs. 0.22 in 1985-86, which was far lower than that of average of all industries, which employed productive capital of Rs. 0.80, Rs. 0.79 and Rs. 0.70 respectively. Similar was the case with respect of requirement of productive capital for employment generation. To generate one person employment for a year, bicycle industry required productive capital of Rs. 13,339 in 1975-76, Rs. 13,844 in 1977-78 and Rs. 31,016 in 1985-86, which was lower than Rs. 38,415, Rs. 44,727 and Rs. 1,10,606 needed by the average of all industries. It implied that average of all industries required productive capital about 3 times in 1975-76, over 3 times in 1977-78 and over 3.15 times in 1985-86 than that required by the bicycle industry. (Statistical Abstracts of India, Various Issues).

Based on the different economic ratios, we found that the bicycle industry was relatively more labour intensive vis-a-vis the average of all industries. However, it was not accompanied consistently by higher productivity. For example, per person output in bicycle industry was of the order of Rs. 49,991 in 1975-76 and Rs. 59,829 in 1977-78 which was higher than that in average of all industries respectively. However, the pattern reversed in 1985-86, when productivity turned out to be lower in bicycle industry (Rs. 1,41,271) than that in the average of all industries (Rs. 1,58,433). This lower level of productivity probably manifests the use of obsolete and outdated technology employed in bicycle industry vis-a-vis the average of all industries, which seemingly employed a relatively better technology in their production operation.

Since, India is merely a price taker in the world bicycle export, it is not possible to control the factors of external demand attempt has to be made to improve the conditions on the internal supply front.

A similar argument has also been advanced by an important study, which has analysed the growth and problems of bicycle industry in India (Business India, 1986). There has been a growing trend for diversification of manufacturing goods. In earlier years, bicycle manufacturers had heavily concentrated on production of bicycles and its parts; then switched over to profit oriented production of fuel-intensive mopeds and motor cycles, implying thereby a change in product and technology. An other factor causing the low level of productivity in bicycles was the way in which labour market was functioning. The labour market has generally been characterised by cut-throat competitive environment among cycle manufacturers. Many times, a group of workers leave their firm and join another bicycle firms, for the sake of more money in the form of advance and marginal wage benefit.

Economic & Social Viability

Industrialisation strategy emphasizing the concentration of manufacturing activities, trade and commerce in

Table 5: Characteristics of Bicycle Industry vis-a-vis the Average of All Industries of India

(in ratio)

Year	Productive capital/ Output (Rs.)		Productive capital/ Employee (Rs.)		Material Cost/ Output (Rs.)		Output/Employees (Rs.)	
	Bicycle	All Industry	Bicycle	All Industry	Bicycle	All Industry	Bicycle	All Industry
1975-76	0.27	0.80	13339	38415	0.81	0.77	49991	48153
1977-78	0.23	0.79	13844	44727	0.84	0.77	59829	56391
1985-86	0.22	0.70	31016	110606	0.89	0.81	141271	158433

Basic Source: Central Statistical Organisation, Department of Statistics, Ministry of Planning, Government of India, *Statistical Abstract, India* Various issues.

The study also underscored that a significant proportion of short-distance movement was met by bicycles in most of the Indian metropolis and small cities. It was found that expenditure on travelling by public transportation was as high as 7 times the expenditure incurred on repairs and maintenance of bicycles. Bicycle being economically cheaper has been within the affordable reach of the middle and poor income class communities, which also serves as an exercise for physical fitness. In sharp contrast to this, the motorised mode of transport (buses, lorries, private cars, motor cycles, scooters, mopeds, etc.) has not only been unviable economically, but also unconducive from the social point of view as it has been the main cause of accidents and environmental degradation.

Considering the significance of non-motorised mode of transportation in general and bicycle in particular, attempt has to be made to improve the travelling condition by bicycles on the one hand and to improve the overall functioning of the bicycle industry on the other. Municipal Corporation, therefore, should embark upon a programme of improving the street lighting, street signals and roads in the urban metropolis. In association with this, the government should also provide incentives, subsidies and capital to improve/import technology for the bicycle industry. The subsidies, incentives and imported technology made available should not be utilised only to maximise profit, but to make the bicycle available at a cheaper rate and also to enhance the labour productivity. We however, do not discourage the motorised mode of transportation. What is needed is in fact the appropriate adoption and innovation of technology, which could make the motorised mode of transport, less fuel-intensive and less cost-intensive and provide these at a rate that common urban inhabitants could afford. This could be achieved by enlarging the scale of production, taking advantages of agglomeration economies, consistent with the long-run broad objective of urban development with equity.

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References

Ahmed, J., "Domestic Demand and Ability to Export in Developing Economies: Some Preliminary Results", World Development, Vol. 4, No. 8, August 1976.

Ball, R.J., Eaton, J.R. & Stuer, M.D., "The Relationship Between United Kingdom Export Performance in Manufacturers and Internal Pressure of Demand", The Economic Journal, Vol. LXXVI, No. 303, September 1966.

Barrett, Richard, *Urban Transport in West Africa,* World Bank Technical Paper No. 81, Urban Transport Series, World Bank, 1988. p. 8

Business India The 'Majestic' Manjals, April 21 - May 4, 1986 (in cover feature) also published in *Bicycle Reference Manual For Developing Countries,* Edited by Barbara Gruhl Kipke, Horb-Nordstetten, Germany, 1991.

Census of India Registrar General and Census Commissioner, Ministry of Home Affairs, 1991 (Series 1 Paper 2 of 1991).

Chandhok, H.L., & Policy Group, -Indian Data Base: The Economy (Annual Time Series Data), 1990.

Cooper, R.A. & Hartley, K., Export Performance and Pressure of Demand, George Allen and Wnwin Ltd., 1970.

DGCI & S., Calcutta, Monthly Statistics of Foreign Trade of India, Various Issues.

Economic Survey Government of India, Ministry of Finance, Various Issues.

Henry G.B., "Domestic Demand Pressure and Short-Run Export Fluctuations", Yale Economic Essays, Vol., 10, No. 1, 1970.

Jacobs, G.D., & Sayer, I., Road Accidents in Developing Countries, Transport and Research Laboratory, Report SR 807, Crowthorne, U.K., 1993.

Maunder, D.A.C, "A Comparison of Cycle use in Delhi, Jaipur and Hyderabad", Edited by Barbara Gruhl Kipke in Bicycle Reference Manual for Developing Countries (Asian Experiences, Horb-Nordstetten, Germany, 1991.

National Council of Applied and Economic Research, Demand for Scooters, 1971.

Papola, T.S. & Sinha, R.C., The Role of Transport in Economic Development: A Comparative Study Between Uttar Pradesh (India) and Japan, Institute of Developing Economies, Tokyo, Japan, No. 26 Joint Research Programme Series, 1981.

Pendkur, V.S., "Non-Motorised Urban Transport in India", Bicycle Reference Manual for Developing Countries, Edited by Barbara Gruhl Kipke, Horb-Nordstetten, Germany, (Asian Experience) 1991.

Replogle, "Sustainable Transportation Strategies for Third World Development," Bicycle Reference Manual for Developing Countries, Edited by Barbara Gruhl Kipke, Horb-Nordstetten, Germany, 1991

Statistical Abstracts Central Statistical Organisation, Ministry of Planning, Government of India, Various Issues.

Smith, D.J., "Stop-go and United Kingdom Exports of Manufacturers", Bulletin of the Oxford University Institute of Economics and Statistics, Vol. 30, No. 1, February 1968.

Work, George, "Transportation, Bicycles Development and the Third World", Edited by Barbara Gruhl Kipke in Bicycle Reference Manual For Developing Countries, Horb-Nordstetten, Germany, 1991; United Nations, Yearbook of Industrial Statistics, Various Issues.

Revised Labour Productivity Estimates for Asian Nations

NPC Research Division

In international economic comparisons, it is conventional to convert the Gross Domestic Product (GDP) or Gross National Product (GNP) of each country to a common monetary unit, usually the US Dollar. For this purpose, the *exchange rates* of the currencies of different countries are used as the conversion factor. Although exchange rates have long served as a yardstick in international comparisons, they do not reflect the relative purchasing powers of the currencies of various countries within their respective domestic markets. Taking cognizance of this limitation, the United Nations launched the International Comparison Programme in 1970, in order to compute Purchasing Power Parity (PPP) adjusted GDP in terms of a common unit called the *International Dollar*[1]. Since then, the ICP has completed four more phases, once in every five years. Phase VI of the ICP, which has the reference year 1990, is nearing completion. A detailed report on the methodology of the ICP can be obtained from the World Comparisons of Purchasing Power and Real Product for 1980, United Nations, (1986). The World Bank has been supplementing the ICP with their regression equations for estimating ICP-type GDP figures for countries and years that are not covered by the ICP[2].

We presented Labour Productivity among select Asian countries in an earlier study [Productivity, 33(4)], using the exchange-rate based GDP figures as the numeraire. But as we noted earlier, these do not reflect the purchasing power disparities among the covered currencies. This is a serious limitation because aspects like employment, wages, product prices etc., are determined by demand and supply forces in the domestic market whereas exchange-rates are determined by supply of and demand for various currencies in the international market.

Here we attempt to overcome this shortcoming of our earlier labour productivity estimates by modifying them for variations in purchasing power of the respective national currencies. For this purpose, we have used the labour data given in the earlier study, i.e., 'Economically Active Population'. Instead of exchange-rate based GDP figures we have now used the PPP based GDP as computed by the ICP during its various phases, which are available for the years 1980, 1985, 1987, 1989 and 1990[3]. The missing values for the rest of the years between 1980 and 1990 have been estimated using interpolation, assuming a constant growth rate between the years for which data are available.

The total GDP thus arrived at, has been allocated to various sectors according to their shares in the total GDP in domestic currencies. The purchasing power parity based GDP estimates for various years are presented in table 1. In table 2, we give the corresponding labour productivity figures.

Compiled by
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1. The *International Dollar* has the same purchasing power over total GDP as the US Dollar in a given year, but purchasing power over sub-aggregates is determined by average international prices rather than by US relative prices.
2. For a detailed treatment, see Sultan Ahmad, 'Regression Estimates of Per Capita GDP based on Purchasing Power Parities', The World Bank (1992).
3. See World Development Report for various years.

Not Adequately Defined	4999	5152	5325	5283	5409	5793	6061	6512	7012	7315
Total	86872	89383	92455	95386	98351	108441	116333	127655	136800	142680
SRILANKA										
Agriculture, Hunting, Forestry & Fishing	5283	5717	6373	6217	7127	7365	7283	7641	7609	8684
Mining & Quarrying	140	139	178	221	226	320	412	543	693	793
Manufacturing	3309	3450	3524	4353	4845	5271	5738	6011	6359	7389
Electricity, Gas & Water	339	390	415	489	553	614	667	704	733	840
Construction	1784	1829	1937	2061	2212	2439	2712	2817	2909	3075
Wholesale, & Retail Trade & Hoteleering	3119	3819	4340	4899	5378	5792	6312	6632	6961	7629
Transport Storage & Communication	2049	2211	2566	3025	3227	3388	3628	3732	3779	4118
Financial, Insurance, Real Estate & Business Services	615	819	916	1059	1196	1274	1421	1542	1676	1865
Community, Social & Personnel Services	1347	1426	1509	1606	1709	1790	1958	1969	2279	2479
Not Adequately Defined	1979	2159	2393	2627	2724	2924	3145	3161	3290	3516
Total	19963	21959	24151	26557	29198	31176	33276	34752	36288	40290
THAILAND										
Agriculture, Hunting, Forestry & Fishing	14956	16405	17768	19563	22705	24210	24580	27950	30876	29042
Mining & Quarrying	3291	3706	3799	4704	5368	5657	6184	7741	9689	10841
Manufacturing	20212	22060	24802	27467	29996	35335	40741	49095	58544	67641
Electricity, Gas & Water	1661	2026	2299	2616	315	3712	4236	4962	6160	6976
Construction	5186	5484	6324	7290	7592	7841	9042	11314	14918	17939
Commerce	13967	14707	16122	18019	20462	22925	26344	31272	37769	42052

Table 1: GDP In Current International Dollars (In Millions)

Industry	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
BANGLADESH										
Agriculture, Hunting, Forestry & Fishing	25021	28015	30449	33180	34794	37257	38977	39371	39483	42125
Mining, Quarrying & Manufacturing	6217	6560	6765	7387	8211	8735	9819	10058	10480	11134
Electricity, Gas & Water	198	246	391	436	481	560	712	842	1100	1148
Construction	2904	3157	3174	3958	4610	4862	5411	6186	6576	6932
Wholesale & Retail Trade & Hoteleering	6434	6364	6970	7117	7636	8234	8932	9382	9964	10242
Transport, Storage & Communication	6524	7105	7929	8580	9347	10020	11575	12221	12916	13418
Financial, Insurance, Real Estate & Business Services	1097	1073	1054	1157	1410	1846	2030	2096	2149	2152
Community, Social & Personnel Services	1704	1599	2039	1968	2710	3383	3801	4186	4527	4841
Not Adequately Defined	9811	10752	11727	12773	43796	15108	16566	18123	19269	20043
Total	59911	64872	70499	76557	82995	90006	97824	102454	106464	112035
INDIA										
Agriculture, Hunting, Forestry & Fishing	153428	163665	184119	194200	204622	202396	203387	233846	249976	295090
Mining & Quarrying	10362	12499	13007	13939	15419	17637	18240	19707	21277	24938
Manufacturing	70225	80813	90172	101220	110625	119093	127854	168054	152594	185469
Electricity, Gas & Water	7770	8949	9764	11367	12946	14374	15520	17295	19611	24038
Cunstruction	25358	26116	28364	31041	34290	35606	36932	38662	41234	48798
Trade & Commerce	53975	61570	65787	72349	82213	87774	92318	100418	108285	131951
Transport, Storage & Communication	23236	26223	28359	32624	37332	40117	43268	46617	52324	62712
Others	77494	90068	95679	107809	120764	130195	139739	149352	170549	203929
Total	421849	469903	515251	564549	618201	647192	677078	743951	814850	976925
JAPAN										
Agriculture, Hunting, Forestry & Fishing	34417	37774	40144	42785	43662	45689	48528	47447	49823	51804
Mining & Quarrying	4232	4596	4489	4214	4097	4546	4406	4557	4294	4731
Manufacturing	278606	304478	331808	369385	404706	420602	464641	512704	562559	618795
Electricity, Gas & Water	31016	34564	38396	39975	44053	47659	50213	54264	57659	65795
Construction	101932	104140	100737	103239	108500	120075	136882	152250	162192	174024
Wholesale & Retail Trade & Hoteleering	282327	308487	336498	354469	381425	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 2 : GDP Per Person in International Dollars

Industry	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
BANGLADESH										
Agriculture, Hunting, Forestry & Fishing	1800	1975	2104	2247	2310	2424	2486	2461	2419	2529
Mining, Quarrying & Manufacturing	2908	3007	3040	3253	3544	3695	4071	4088	4174	4347
Electricity, Gas & Water	3479	4237	6591	7201	7790	8889	11076	12834	16430	16819
Construction	7048	7511	7401	9044	10326	13593	11643	13045	13593	14045
Wholesale, & Retail Trade & Hoteleering	2339	2267	2434	2436	2561	2707	2878	2963	3085	3108
Transport, Storage & Communication	7298	7790	8521	9036	9648	10138	11478	11878	12304	12528
Financial, Insurance, Real Estate & Business Services	9541	9147	8806	9475	11319	14521	15650	15836	15917	15620
Community, Social & Personnel Services	879	808	1010	956	1290	1578	1738	1871	1988	2084
Not Adequately Defined	6948	7463	7978	8517	9016	9678	10401	11152	11622	11848
Total	2537	2692	2867	3052	3243	3447	3672	3769	3839	3959
INDIA										
Agriculture, Hunting, Forestry & Fishing	947	992	1095	1134	1173	1139	1124	1269	1332	1544
Mining & Quarrying	7675	8913	8929	9211	9803	10801	10754	11185	11626	13117
Manufacturing	2636	2901	3097	3325	3475	3578	3674	3795	4012	4664
Electricity, Gas & Water	7472	8051	8219	8953	9540	9910	10011	10439	11074	12701
Construction	6436	6259	6418	6632	6917	6782	6642	6565	6612	7388
Trade & Commerce	3618	3916	3970	4143	4468	4526	4508	4663	4771	5517
Transport, Storage & Communication	3580	3887	4043	4475	4925	5091	5282	5475	5911	6815
Others	3669	4182	4357	4814	5289	5592	5886	6169	6908	8101
Total	1776	1929	2062	2203	2351	2399	2445	2618	2796	3261
JAPAN										
Agriculture, Hunting, Forestry & Fishing	5770	6489	7066	7716	8067	8649	9413	9429	10145	10808
Mining & Quarrying	40173	44731	44802	43119	42985	48907	48598	51535	49797	56251
Manufacturing	20810	22500	24260	26720	28964	29782	32551	35537	38578	41984
Electricity, Gas & Water	89583	100519	112433	117865	130784	142462	151133	164451	175942	202151
Construction	19018	19516	18961	19518	20603	22901	26222	29394	31344	33779
Wholesale, & Retail Trade & Hoteleering	21956	23752	25652	26753	28502	31099	32690	34220	36098	39612
Transport, Storage & Communication	18663	19735	21705	23781	25681	27789	29354	31447	33815	36212
Financial, Insurance, Real Estate & Business Services	73805	76539	82644	89372	95455	106435	115195	121917	129918	132678
Community, Social & Personnel Services	7199	7492	7759	7915	8022	8421	8535	8471	8440	8469
Not Adequately Defined	255347	229313	206721	182727	159639	144702	125590	108528	93117	78818
Total	18814	20096	21476	22906	24443	26256	28149	29927	31804	34041
REPUBLIC OF KOREA										
Agriculture, Hunting, Forestry & Fishing	3653	4242	4777	5011	5649	6442	6598	7577	8445	8489
Mining & Quarrying	16476	15220	16037	16822	18109	20397	21130	21324	23214	19081
Manufacturing	10278	10739	11735	13285	14011	16366	19344	21145	22294	23024
Electricity, Gas & Water	61017	65559	82824	103599	120202	154588	179565	197522	229778	266665
Construction	10599	12105	13673	13702	13860	14133	15599	16197	18699	21539
Wholesale, & Retail Trade & Hoteleering	6348	6752	7041	7395	7945	9221	10633	11471	12147	12709

PAKISTAN										
Agriculture, Hunting, Forestry & Fishing	2530	2612	2523	2720	2889	3065	3225	3532	3725	3893
Mining & Quarrying	7032	7528	8453	10176	13782	16622	20842	24476	30024	25283
Manufacturing	7466	7721	8263	8484	8937	9651	10620	11064	11729	12052
Electricity, Gas & Water	15514	13368	12589	10242	9364	8656	8410	7960	7607	6801
Construction	4792	4595	4696	4975	5299	6106	6557	6818	7222	7481
Wholesale, & Retail Trade & Hoteleering	6914	7309	7654	8199	8652	9295	10229	10897	11475	11832
Transport, Storage & Communication	9091	9534	10287	10606	10961	11861	12751	12352	13275	14057
Financial, Insurance, Real Estate & Business Services	42510	44113	46831	47447	50217	54238	57941	62385	66976	69798
Community, Social & Personnel Services	2874	3070	3295	3235	3348	3559	3720	4034	4165	4137
Not Adequately Defined	6408	7176	8355	8557	8846	9316	9960	10520	11090	11397
Total	4262	4461	4664	4875	5147	5536	5961	6337	6710	6935
PHILIPPINES										
Agriculture, Hunting, Forestry & Fishing	2784	2841	2792	3109	3415	3784	3803	3990	4166	4255
Mining & Quarrying	28131	25064	25009	24251	25509	24203	22845	24554	2555	24265
Manufacturing	17957	18547	19571	20207	20244	22483	25001	28217	30730	31933
Electricity, Gas & Water	27186	29573	32537	38324	43803	57243	65110	69348	72990	76549
Construction	18046	19148	18937	16303	13031	11447	14149	15905	18750	20585
Wholesale, Retail Trade & Hoteleering	12369	12331	12873	13877	14394	15343	16097	16864	17327	17553
Transport Storage & Communication	9454	9801	10133	10471	11197	12376	13181	13942	14830	15477
Services	4221	4265	4438	3809	3562	4078	4381	5137	5450	5718
Not Adequately Defined	31544	33118	34865	35230	36740	40078	42709	46745	51269	54477
Total	5603	5596	5608	5594	5564	5903	6079	6385	6532	6484
SRILANKA										
Agriculture, Hunting, Forestry & Fishing	2816	3040	3380	3289	3761	3877	3824	4002	3975	4525
Mining & Quarrying	4153	3730	4348	4904	4575	5881	6894	8266	9589	9971
Manufacturing	8095	8286	8307	10072	11006	11752	12557	12913	13408	15087
Electricity, Gas & Water	21177	23169	23403	26203	28146	29677	30640	30728	30682	33086
Construction	13320	13307	13736	14253	14893	16010	17343	17560	17675	18209
Wholesale, Retail Trade & Hoteleering	7131	8525	9457	10422	11169	11742	12493	12814	13129	14047
Transport, Storage & Communication	10266	10956	12581	14667	15476	16073	17023	17320	17346	18699
Financial, Insurance, Real Estate & Business Services	10811	13251	13647	14529	15107	14813	15213	15199	15218	15595
Community, Social & Personnel Services	2291	2384	2478	2591	2709	2787	2996	2960	3366	3599
Not Adequately Defined	5358	5751	6274	6775	6913	7301	7727	7639	7824	8227
Total	3979	4325	4700	5104	5542	5843	6156	6345	6537	7159
THAILAND										
Agriculture, Hunting, Forestry & Fishing	878	941	996	1066	1215	1266	1256	1395	1506	1384
Mining & Quarrying	35489	39715	40460	49791	56468	59144	64253	79940	99436	110579
Manufacturing	14339	14652	15423	15990	16348	18030	19462	21957	24513	26515
Electricity, Gas & Water	24500	27318	28335	29366	32487	34958	36472	39057	44327	45889
Construction	13854	13715	14809	15985	15586	15071	16272	19064	23536	26499
Commerce	8183	8110	8367	8801	9406	9918	10726	11983	13621	14273
Transport, Storage & Communication	13743	15387	16474	18021	19688	21439	22578	24650	27289	29019
Services	4950	5288	5702	5794	6317	6581	7039	7636	8157	9095
Not Adequately Defined	17357	19700	21449	23195	26280	28314	30908	33574	36002	36937
Total	3532	3799	4078	4397	4822	5201	5618	6362	7199	7704

be obtained by:-

- Using one or more static rinse baths in sequence before continuous flow rinsing tank
- Agitation of work piece during rinsing

metal bearing solid waste from wastewater treatment plant will reduce leading to reduced disposal costs.

Compiled by
P.K. Gupta

Pollution Audit in Small Scale Electroplating Units

NPC Pollution Control Division

Electroplating industry is characterised by both jobbing as well as captive production arrangements. Small scale electroplating units are mostly "jobbers" depending

A number of ancillary operations also adds to the pollution load. These include:

- Storage of chemicals

Energy Consumption Trends in Glass Industry

NPC Energy Management Division

Glass Industry produces a variety of products in domestic and industrial sectors, prominent among which are (a) glass bottles and containers of all type for pharmaceuticals, soft drinks, foods, breweries, chemicals, etc. (b) sheet glass, figure and wired glass, safety glass and mirrors (c) electric lamps (d) Lampware, tableware, press ware, syringes, bangles, beeds, etc. in small scale sector. This energy intensive sector produces about 11 lakh tonnes of finished products. Energy constitutes about 25% of the manufacturing cost. The Glass tank furnace is the single largest equipment consuming about 60-80% of the total energy consumed in a glass plant.

Energy Consumption Trends

In a recent study carried out by NPC, data from 14 units were collected to estimate the energy consumption trend in this sector. The energy cost as a percentage of manufacturing cost in three sub sectors of glass industry is shown in Table 1. The major forms of energy used in glass industries in India are fuel oil, RFO, LSHS, LDO, LPG, Natural Gas and Electricity. In terms of energy variations are observed in the share of thermal and electrical energy in the different sub sectors(container, sheet glass, and shell and tube). The variations observed are given in the Table 2. The share of electrical energy is much less in sheet glass units when compared to container and shell and tube units. Table 3 depicts the key plant data, correlating Glass to Oil ratio with the capacity, cullet recycled, compaign life, capacity utilisation and waste heat recovery aspects in the 14 units. Similarly Table 4 gives the trends observed in electrical energy consumption for the year 1989-90. Glass to oil ratio is the ratio of actual glass drawn from the Glass tank furnace (in TPD) to the oil fired in the furnace (in TPD) during melting land refining (Expressed in equivalent RFO), Table 5 presents the trends of the glass to oil ratio encountered by the various sectors of the glass industry. Table 6 presents the variation in specific electricity consumption.

Table 1 Energy Cost as a Percentage of Manufacturing Cost

Sub Sector	% Energy cost as total manufacturing cost.
Container	19-24%
Sheet Glass	30-36%
Shell and tube	11-50%

Table 2 Variation in Specific Energy Consumption

Sector	Fuel Oil %	LDO %	LPG %	Electricity %
Container	52 to 60	1 to 9	4 to 7	29 to 40
Shell & Tube	45 to 60	—	11 to 22	19 to 41
Sheet Glass	87 to 90	2 to 5	0.3 to 0.8	7 to 8

Specific Energy Consumption

The specific energy consumption of a glass unit is the sum total of energy consumed in different operations (expressed in giga Joules) divided by the total saleable output of glass products (tonne). The overall variation of specific energy consumption norms of sample surveyed units producing various types of glass are given in Table 7.

Factors Affecting Performance

A number of factors contribute to variations in the Glass to oil ratio observed in each of the sub sectors. A few prominent ones are highlighted below:

1. Lower scale of operation due to shift in demand to other materials and technological obsolescence resulting in low glass to oil ratio.

Table 3 Key Plant Data for Fourteen Respondents to the Study

Sector	Capacity of Furnace (TPD)	Fuels Used	Cullet Received (%)	Campaign Life (YRS)	Capacity Utilisation (%)	Type of Heat Recovery	Air Pre-Heat Temp. (°C)	* Glass to Oil Ratio
CONTAINER								
Unit-1	60	RFO, LDO, LPG	21	7	84,83,97	Regenerator (Double pass)	1100	6.2, 6.0, 6.3
Unit-2	75	RFO, LDO, LPG	25	5 1/2	70, 95, 96	Regenerator (Single pass)	1315	6.5, 6.0, 5.5
Unit-3	60	LSHS, RFO, LPG	30	4 1/2	62, 72, 75	Regenerator (Multi pass)	1200	-, - , 5.8
Unit-4	120	LSHS, FO, LPG, LDO	40	5	40, 79, 79	Regenerator (Double pass)	1200	6.7, 7.8, 7.9
Unit-5	130	RFO, LDO, LPG	40	6	–, –, –	Regenerator (Double pass)	980	5.3, 6.9, 6.8
SHEET GLASS								
Unit-1	75,110	RFO, LDO	20	5	96, 91, 88	Regenerator (Double pass)	1200	3.5, 3.5, 4.0
Unit-2	60, 70	RFO, LDO, LPG	25	6	96, 108, 97	Regenerator	1150	3.5 (F), 3.5 (F), 3.5 (F), 2.9 (P), 2.9 (P), 2.9 (P),
Unit-3	60	RFO, LDO, LPG	20	7.8	90, 92, 90	Regenerator (Multi pass)	1140	2.8, 3.0, 3.0
SHELL & TUBE								
Unit-1	15	RFO, LPG	60	5	63, 61, 59	Regenerator (Ceramic)	850	2.8, 2.7, 2.6
Unit-2	15	RFO, LPG	60	4.5	109, 102, 88	—Do—	1000	1.8, 2.2, 2.3
Unit-3	17	RFO, LPG	40	7.5	74, 74, —	Recuperator Regenerator	1150, 1250	- , - , 3.0
Unit-4	15	RFO, LPG	30	4	- , 103, 71	Recuperator	800	1.9, 2.0, 2.1
Unit-5	15	RFO, LPG	50	6	- , 75, 45	Recuperator	800	1.7, 1.7, 1.7
Unit-6	25	RFO, LPG	65	5	- , - , -	Recuperator	750	- -, 2.0

* = Figures are for three years period 1987-88, 88-89, 89-90. (F) = Fourcault; (P) Pittsburg
Glass to oil ratios have been expressed as equivalent RFO.

2. The average compaign life of glass tank furnace (i.e. number of years of its useful life) is about 4.5-5 years as against about 6-8 years for units abroad mainly due to inferior quality of indigenously manufactured refractories.

3. The proportion of cullet recycle which helps in quicker fusion and faster melting of glass batch was observed in the range of 40 to 60% of the batch contents. Higher proportion of cullet recycle reduces energy consumption.

4. Lower capacity utilisation due to higher rejection rate, frequent interruptions of power supply, down time, etc. In indigenous units, the overall variations are observed between 40 and 108% in container and shell & tube units, the general trend is in the range of 70% to 90%. In case of sheet glass units, it is in the range of 55% to 100%.

5. The rejection rates in Indian units are 15-20% for container 2% for sheet and 25-35% for shell & tube units. These are much higher in comparison to units abroad. Reasons for higher rejection rates are mentioned below:
   - Frequent interruptions in power supply.
   - Age of the melting furnance.
   - Frequent job change according to market demand.
   - Run down of silica refractory, affecting glass melt quality.

6. Recuperators, of late, are having increased acceptance in smaller units. Gas tight construction gives advantages that higher pressures can be used in combustion system, facilitating use of burners with well designed Registers. Also, the extent of heat recovery depends on the mode of heat transfer such as re-radiation, Convection or combination of both. However, in Indian Industries only radiation type recuperators are prevalent with many definite advantages over recuperators such as lower cost, low installation area, higher efficiency under turndown conditions and less complexity in operations.

7. Broadly, the extent of sophistication in instrumentation and control system employed in batch weighing and monitoring system, temperature measurement, recording and correcting systems oil flow meters for fuel oil measurement and combustion control systems etc. have considerable bearing on the performance of the furnace.

8. The sheet glass manufacture in our country are basically by conventional PPG or Fourcault process. The former has marginally higher specific energy consumption by about 6% to 8%.

The factors responsible for variation in specific electricity consumption are:

1. Reciprocating compressors are commonly used for compressed air while screw compressors are more energy efficient. Also, in mould cooling, normal timed cooling air can be a preferred choice compared to radial cooling. Reduction in energy consumption is to the tune of 50%.

2. Adoption of electric boosting technology for improved melting is well established and needs to be propagated on a wider scale in Indian units since the convection currents generated in the tanks assists in improving the overall effectiveness of the fuel firing system and permits melting additional quantity for the same area of the tank.

3. Wide variation observed in case of shell & tube units, is partly due to rejects being high and partly due to inert gases being purchased or manufactured.

4. Frequent interruptions in power supply.

5. Most of the lehrs for annealing are of gravity design in which radiation is the predominant mode of heat transfer. Gravity Lehrs are being replaced with modern recirculating Lehrs which are much shorter and more efficient.

Table 4 Trend of Electricity Consumption in Units

Sector	Capacity of the furnaces	89-90 kwh/MT
Container		
Unit 1	60	324
Unit 2	75	457
Unit 3	60	327
Unit 4	120	330
Unit 5	130	350
Sheet Glass		
Unit 1	75, 110	123
Unit 2	60, 70	103
Unit 3	60	350
Shell & Tube		
Unit 1	15	1149
Unit 2	15	400
Unit 3	17	1273
Unit 4	15	262
Unit 5	15	313
Unit 6	25	350

Table 5 Trend of Glass to Oil Ratios

Sector	Glass to Oil Ratio MT/MT	
	Minimum	Maximum
Container 60-75 TPD	5.5	6.5
> 75 TPD	< 5.3	7.9
Sheet Glass	2.9	4.0
Shell & Tube	1.7	3.0

Table 6 Trend of Electricity Consumption

Sector	Specific elect. consumption KWH/MT	
	Minimum	Maximum
Container	321	460
Sheet Glass	94.5	174
Shell & Tube	165	1273

Table 7 Specific Energy Consumption in the Sample Units

	Specific Energy Consumption GJ/Ton	
Sector	Minimum	Maximum
Container	9.3	13.8
Sheet Glass	14.7	15.0
Shell and Tube	31.6	34.3

Basis: GCV of RFO, LDO, LPG are 10280 Kcal/Kg. 10700 Kcal/Kg. and 11000 Kcal/kg. respectively. Sp. gravity of LDO = 0.9, Sp. gravity of RFO = 0.95

Compiled by
N. Sajith

News & Notes

FROM OEM TO ODM TO "OBM"

OEM (original equipment manufacturing) is usually more oriented toward manufacturing. Moving from a manufacturing emphasis to building R & D capability is a mandatory journey to attain ODM (original design manufacturing), which leans more toward production and design.

In an OEM situation, the customer buys a finished product from the manufacturer, there is little modification of the product, and the customer's label is attached. OEM requires strong mass production as well as limited and there is an extremely high standard of quality. Customers except a superior product, delivered on time. Manufacturing delays or quality flaws are unacceptable and will create extra cost for the manufacturer.

The cost structure is extremely tight for the OEM manufacturer. It's not unusual for customers to go through the product's bill of materials with a fine-tooth comb, then calculate the cost of each part with their own databases. This is critical to the total cost of the product because the OEM customer has large buying power with the parts vendor, which it can enhance by mixing products across product lines. It can thereby negotiate for lower prices for the necessary parts and refer the revised prices to the manufacturer's purchasing department. The total cost then equals material cost + direct labor cost + overhead. Gross profit will be added on of the cost. The cost will be reviewed by both parties at set intervals, for instance, annually. The OEM manufacturer can thus gain benefits: (a) relatively large business revenue, (b) fixed "survival" gross margin, (c) in-house manufacturing capability.

In ODM, on the other hand, the customer designs the product and supplies the design to a manufacturer, who does not necessarily have any design engineering capability. The manufacturer must, however, be able to perform product engineering, quality control, manufacturing engineering, and so on, to turn the design into an actual product. For the manufacturer, valuable experience in that particular product line is accumulated through this process.

In OBM (original brand-name manufacturing), one creates one's own brand-name product, starting conceptualization to product development to manufacturing to market development and product sales. The difference here is the additional marketing effort required. Developing and establishing a marketing channel requires significant long-term investment. Successful OBMs yield higher margins, customer loyalty, and low entry barriers for launching new products.

The mission is to differentiate products from those of its brand-name customer and at the same time build one's own channel that will make launching new products much easier. Microtek is one of the few manufacturers in Taiwan that has progressed from an OEM to an OBM.

Microtek, a scanner manufacturer, is always on the leading edge of technology. In a field primarily dominated by Japanese vendors, Microtek differentiates itself by offering total system in generation solutions, not just a hardware box. the Japanese make good scanner boxes but do not provide software box. The Japanese make good scanner boxes but do not provide software solutions, not even driver software in some cases. So customers need to look elsewhere for other pieces to solve the system puzzle. With Microtek, contrast, when you buy a Microtek scanner, the driver software as well as the most popular and appropriate application software comes bundled. This software bundle concept was initiated by Microtek and is not used by virtually all other scanner vendors.

Strategic decisions are critical when OBM manufacturers want to stay ahead of the competition. For instance, in 1989, when Hewlett Packard entered the market with its gray-scale scanner, Microtek reacted quickly. Within a matter of months, Microtek introduced a whole human health and changes to the balance of solar radiation intensity.

Research requirements

- Determination of the relative carrying capacity off ecosystems to wet and dry depositions as well as to photochemical smog.
- Investigation of the CO_2-fertilisation effect in natural ecosystems subject to concurrent global warming.

Climate Change

If the behaviour of mankind does not alter then, according to the best available estimates, the manmade increase of the greenhouse effect will induce an average *global warming* of + 3°C during the next century. This is more or less the same order as the transition in temperature from ice age to warm age. Without enacting effective countermeasures, widespread changes are inevitable, the most significant of these being a shift of *precipitation zones* and *a sea level rise* of 65 ± 35 cm by the year 2100.

Recommendations for action:

- Immediate reduction of greenhouse gas emissions in all industrialised countries, most of the oil-exporting countries, and those tropical forest countries with high per capita emissions.
- Political guidelines to increase energy and transport efficiency.
- Preventive measures with respect to sea level rise and changing precipitation patterns.

Research requirements

- Identification of regions, social groups and economic activities which are particularly relevant for and sensitive to climate change.
- Investigation of ecosystems which, in the event of climate change and an increase in the CO_2 content of the atmosphere, are capable of storing larger quantities of carbon.
- Determination of climate damage functions – the costs invoked due to the failure to carry out measures in time to reduce or mitigate climatic changes.

Population

During the nineties the global population is expanding annually by nearly 100 million people, most of whom (80 million) will settle in urban areas. Even with a drastic decrease of the current average birth rate the present world's population of 5.52 billion will at least double by the middle of the next century.

Rapid urbanisation and *massive migration* are two further areas of concern, both of which will affect the industrialised countries because of increasing immigration pressure.

Recommendations for action:

- Fighting the causes of population growth by alleviating poverty, providing equal rights for women, recognising the right of family planning, reducing infant mortality and improving education.
- Reduction of migration due to environmental reasons, and caring for environmental refugees.
- Implementing regional and city planning, in order to better direct the urbanisation process.

Research requirements

- Ascertaining of the environmental consequences of population growth with regard to induced resource use, emission and waste.
- Determination of the optimal carrying capacity of urban structures.
- Analysis and prognosis of international migration.

Harmit Grabl, Chairman, German Advisory Council on Global Change Annual Report.

THE TEN COMMANDMENTS
(for successful field work)

(1) Do not refuse the offered glass of water and then reach for your mineral water bottle.

(2) Do not insist on paying for food given to you as a hospitable gesture.

(3) In a village meeting, do not insist that you sit on the ground if the village leader feels that you should sit next to him on a chair. Follow village protocol.

(4) Do not antagonise the village power groups by creating parallel institutions without their participation.

(5) Be aware that the mode of transport you used to reach the village may affect respondents' answers to your questions.

(6) Do not make false promise.

(7) Do not barge in if the respondent is not interested in talking to you.

(8) In a village meeting, spare some time for all the group representatives to be heard.

(9) Do not insist on women's participation in village meetings, but give them an opportunity at a later stage to make voices heard.

(10) Keep your eyes open at all times while in the filed.

Excerpts from "Developing Stories" by Peter Firstbrook.

SMALL BUSINESS FROM URBAN WASTES

Studies in slums in various large cities of developing countries show that, while the majority are working gainfully, they remain poor. The efforts of both governmental and non-governmental agencies are now geared to building upon the existing skills and experience of the underprivileged. Capital to start up small businesses is scarce; ingenuity and careful planning can make a great difference to whether employment projects succeed. This is an account of one small pilot project in New Delhi where the employment created had the added benefit of helping with solid waste problems.

For a two-year period, the International Labour Office (ILO) ran a pilot project in selected slum areas of Delhi to explore ways of starting small businesses or developing existing ones so as to create new jobs, develop skills and raise productivity and thus incomes. Shoe renovation was one of the skills included in the work done at Raghubir Nagar by the ILO team. This squatter settlement consists of about 4000 *jhuggis* (shelters constructed from waste materials and mud). Thirty-five families are engaged in shoe renovation and the settlement itself provides most of the raw materials as well as the final market. The source of old shoes that can be remade is the traditional *feriwallah*. The *feriwallahs* of Raghubir Nagar are mainly women from Gujarat state. They go to better-off areas and obtain used shoes and clothing from housewives by bartering steel utensils and crockery items. They then sell these in the daily local market, which is now housed in a market area constructed by the Delhi Development Authority Slum Wing. Among the 4000 households, there are approximately 3000 women doing this work, so there is a ready supply of recyclable clothing available in the area.

From the original group of families selected by the ILO project team, thirty-five have settled for the work of shoe renovation. The project team taught the skills to repair and substantially remake the shoes, including redying. This is, in fact, recycling of wastes and it is estimated that more than 10,000 old shoes are put back into use each month in the Delhi urban area, rather than going to the garbage dump. At first, there was an attempt at co-operative organization of the enterprise, but this did not work successfully as some of the renovators were not used to a co-operative system; the better workers felt they were impeded by the slowness or unreliability of some others. There were also problems on the marketing side. After discussion and re-shaping, the project emerged as one for self-reliant development. The participants were e ·bled to obtain bank loans, open savings accounts, and to upgrade their skills. They went on several study tours to observe different styles of production in shoe making. Many of the participants joined an informal society, which may eventually be registered under the Societies Registration Act. This group functions for mutual aid and also social and cultural activities for the families, Over a period of 16 months the shoe renovators developed confidence that they could run a business, that they have marketable skills. The success of the shoe renovators has led to a 30% increase in persons entering this trade in the past year; at the same time, the shoe renovators have improved their earnings.

Besides shoe renovation, there are also businesses based on paper-bag making, toy making, and selling old clothes. Most of the work depends upon re-use or recycling in some way. The work thus indirectly reduces waste quantities for the city. In addition, the "raw materials" are always in good supply and cheap enough to allow a further profit for the recyclers. There appear to be two main factors in the success of the small business program of the ILO in selected Delhi slums. The activities chosen are ones that do not have a "motivation log". That is, people could start work almost straight away, using skills they possessed, with further trainings. Secondly, management approach has been taken, as against a subsidy or welfare approach. The people have been able to improve their earnings from their own efforts; they are not kept going by charity.

The small business promotion approach does not solve all the problems of families in a squatter settlement but, in terms of developing skills and independence, if offers a way forward that can be replicated in similar settlements in India. The development of enterprises based on waste recycling has great potential in countries like India because there are familiar with waste recovery and some aspects of recycling, and because the use of secondary materials means that the operating costs can be kept quite low.

Raj Prasad & Christine Furedy
ILO, New Delhi & York University, Toronto

ORGANIC MANURES

An area of long term policy which acquires great importance in the present context is the promotion of organic manures. The dangers of indiscriminate and careless use of chemical fertilisers for the health of the soil and the quality of ground water are not widely recognised. The interests of sustainable, high productivity agriculture consistent with a healthy ecological environment would be better served by promoting fuller, more efficient exploitation of crop resides, animal and human wastes as sources of manure.

Crop resides are not used to any significant extent in India for manuring; they are used to feed animals and this will continue to be the case for the foreseeable future. Animal wastes – currently most important source of manure – are only partially used for this purpose. A sizeable part is not collected; and another sizeable part is used for domestic fuel. The portion used as manure is indifferently prepared and consequently has a low nutrient extent. Substantial improvements in the quality of farm yard manures and their nutrient content is known to be feasible through better techniques of compost preparation. That the overall nutrient content of FYM varies between 1.4 and 4.2% (Roy *et. al* 1980) is indicative of the large scope for improvement. A recent study (Goldenberg *et. al* 1988) estimates the nitrogen content of FYM as currently used at 0.5 per cent which is about one fourth of the nitrogen content of bio-gas plant slurries. Use of dung for bio-gas not only increases the nutrient content, but practically all the nutrient content of dung currently used for fuel can be recovered for use by crops. Both would bring down the cost per unit of nutrient from manures and provide a stronger incentive to shift from chemical fertilisers. Any increase in the rate of collection will further augment the potential.

The potential contribution (in terms of the 3 major plant nutrients) at the current level of production (150 million tones dry weight) is around 2 to 6 million tones (depending on the efficiency) and will almost certainly increase over the next decade or so. If even half the potential for enlarging the quantum and improving quality of farm yard manures exploited in the course of the coming decade, we can save some 2 million tones (nutrients) in the requirement of fertilisers a year. More efficient use of fertilisers – by say 10 per cent in the course of the next decade – would save another 2 million tones. The potential saving works out to about a third of the present level of consumption. Besides substantial savings of capital and foreign exchange, this would make for greater balance in the way of nutrients are provided and in a manner which is more desirable from the environmental view point.

This potential however cannot be exploited with the kind of limited and subsidy-oriented programmes for developing rural and urban compost. The centre piece of the programme has to be on accelerating the pace of biogas generation in rural areas. So far an estimated 1.4 million biogas plants – of the most part individually owned – have been set up; and the target is to add another 750,000 in the course of the eighth plan. At this rate, less than 5 per cent of the country's cultivating households would be covered by the end of the eight plan.

Accelerated spread of biogas plants is highly desirable but cannot be achieved unless defects in design, the predomination of individual against community gas plants, lack of repair and servicing facilities and other deficiencies are overcome. A systematic expert assessment of the operating experience of different designs in different regions (in terms of gas output per unit of input, capacity utilisation, capital costs, frequency of break downs and other relevant dimensions) is an essential first step to identify the more significant sources of inefficiency and high costs. This should be the basis for programmes (including research an design) to bring down costs.

An obvious way to cut costs is to encourage community plants and take advantage of scale economies: larger plants cost less in term of investment per unit capacity. But this requires setting up workable collective arrangements for pooling dung and distributing the gas and slurry. An important part of the arrangement is to work out acceptable rules for the sharing of costs and benefits among members, and to enforce these rules in a fair manner. This cannot be accomplished through subsidies.

Community or groups will be accepted only if their costs are significantly lower and/or their benefits substantially higher than in the case of individual plants. It is therefore important to study actual experience or the successful and the non-so-successful bio-gas plants of different scales and design, identify the source of cost differences and learn from the successful ones ways of reducing collection, processing and handling costs. At the same time, users should be made aware of the magnitude of direct and indirect benefits (in terms of reduced costs, savings from substitution of wood fuel by gas and from the augmentation of nutrients for crops) from group/community gas plants. Workable cost and benefit sharing arrangements are more difficult but not impossible. Experiments like the one at Ungra village in Karnataka need to be property documented and made widely known as possible models for adoption on a wider scale. Perhaps it is desirable not to insist on village wide plants with a strong emphasis on a particular pattern of "equitable" benefit distribution. Government Policy should give room for trying out different types of arrangements (including groups and even private ownership) to exploit scale economies and promote more efficient ways of recycling animal and human wastes.

In so far as measures to encourage use of manures and improve fertiliser use efficiency are successful, the rate of growth of demand for fertiliser will be dampened. This is as to should be. There is nothing inherently important about the level of consumption of fertilisers; what is relevant is the outcome in terms of output. and if a given of output can be achieved with a smaller quantum of nutrients, it would be the most telling index of the success of the policy. Obviously, one cannot expect dramatic early results. In any case, given the necessity for sustained agricultural growth to meet rising demand, one must expect the requirements of chemical fertilisers to remain large and also to grow, though perhaps at a more moderate rate than before. Ensuring that the requisite supplies are available in the most economical manner therefore remains an important issue.

A. Vaidyanathan
L.S. Venkata Raman Memorial Lecture,
Institute of Social and Economic Change, (1993)

INDUSTRIAL LOCATION

The general theory of location of industries is that under a system of free play of market forces, assuming perfect mobility of the factors of production, industries tend to be located at the point of minimum comparative cost. The underlying assumption is that the overriding consideration in the allocation of resources as far as the entrepreneur is concerned is economic rationality – maximisation of profit and minimisation of cost. Nearness to raw materials, cheap labour, availability of power, capital, etc. are relevant only with reference to their costs and returns. Regional policy in most countries is meant to modify market forces to influence the decision making of existing and prospective entrepreneurs. In India too the government works via incentives and influences which have a direct or indirect bearing on costs and returns.

While the location and movement of industries are influenced by profit in private enterprise, there are several other factors which may have to be taken into consideration. It may be that the location decisions of many a small-scale entrepreneur are not made on a strict calculus of costs and returns. Some may prefer a steady return to high profit. In regard to industries which are footloose, the choice of location from alternative possibilities may be a matter of convenience rather than high profit. On this question, Harry W. Richardson says: "Profit maximisation is an unsatisfactory goal for location decision-makers for several reasons. For most types of establishments a location decision, once taken, must stand for a long time because of heavy relocation costs .... and enterprise may place a great deal of emphasis on security .... There is increasing evidence, though much of it is impressionistic, that the location decision, more than most managerial decisions, has to take into account 'psychic income' influence and other personal factors which are not easily compatible with narrow definitions of economic rationality"

At any rate the fact that many entrepreneurs make decisions within a certain spatial or distance horizon has to be taken note of seriously. Obviously, distance here has a broader meaning than implied either by mileage or transport cost. The psychic costs of moving (e.g. leaving familiar surroundings), differences in psychic incomes between regions of origin and destination (which is partly a function of social distance), uncertainly about future prospects owing to lack of local influence, preference for sons of soil, information, communication gaps, etc. may seriously influence the distance horizon and hence mobility from familiar locations.

It is not exactly a question of geographical distance, but of social distance. Distance horizons of entrepreneurs may vary from individual to individual. An educated engineer may have a wider horizon of space then a retired Revenue Officer even though they may have the same initial capital resources.

M.A. OOmmen,
Essays on Kerala Economy
Oxford & IBH Publishing Co. 1993

Book Review

Total Project Management – The Indian Context: by P.K. Joy, Macmillan India Ltd., 1993, 590 p. Rs. 385.00

A number of books on Project Management, written by Indian and foreign authors, enter Indian libraries every year. However, the book on Total Project Management by Dr. Joy has many features relevant to Indian projects. The book provides a broad spectrum of time and cost over runs in the various public sector meaga projects, and the causes thereof. To scarce conserve financial resources it is imperative to select chief executives are deeply committed to the projects and who firmly believe in sound project management practices. The book illustrates a number of cases where committed chief executives, despite heavy odds, have succeeded in achieving the desired project objectives with little or no cost and time overruns.

The book should have special significance to Indian project managers as it provides a comprehensive overview of the steps required and procedures involved in getting "project clearance" from the various central and state agencies and also on project financing. The author candidly states that Indian project managers have to acquire the habit of doing homework with great precision. The author has ably dealt with the techniques of project management. This should enhance the utility of this book from the point of view of the Indian managers.

More than 75 per cent of the total project cost is accounted for by the materials procurement, construction and related activities. Obviously therefore, these activities acquire considerable importance once the "go ahead" signal has been given to the project by the sanctioning authority. The author has dealt with the various issues involved in the materials and construction management which become very vital in the project execution stage; construction management is itself a vast and complex subject having extra-ordinary ramifications on timely completion or time overruns.

The author has mentioned that just-in-time (JIT) based supply aid inventory system is not workable for the Indian projects for quite some time to come. May be he is right based on his experience. But if this method could gain ground in the normal production activities (where similar argument prevailed a few years ago), it should have application in project based materials management as well. The problem is that JIT requires meticulous planning, self discipline and total integration of vendor and buyer and we hesitate to work under this type of demanding discipline and confidence based work culture and prefer to build up a massive inventory which after project completion becomes non-moving inventory items-causing huge losses or capital lock-up.

The author has rightly mentioned that one of the greatest challenges for the top management is to acquire the deep commitment of the workers to achieve project objectives. The most pertinent question which must be answered is how much the top management/chief executive is committed to the project? If he is a committed individual, he will have no difficulty in bringing together a team of men who are equally committed to the objectives of the project, of course, the top management needs to have the added quality of leadership – leading people by setting personal examples of highest standards. The author has quoted a number of instances supporting this viewpoint. Incidentally, the author has developed his own Needs-Rewards-commitment model (chapter 14) which should get Indian managers' attention. It is a better alternative to depending solely on Maslow's, Herzbergo's Mcgregor's and other renowned western researchers.

Though it is needless to mention that for successful completion of projects, effective control of time, cost and quality are essential requirements, most of the books on project management lay a lot of emphasis only on control of cost and time. However, Dr. Joy draws far greater attention to the quality aspects which had been a neglected area. He not only emphasises the quality of materials procured or quality of works executed, but also the quality of objectives to be achieved. Various techniques of quality control, quality assurance and promoting participative work culture through quality circles have been discussed in the book.

With the passage of every day, the human society is showing increasing concern towards improving and upgrading the environment and for the social upliftment of the people. No project, however economically beneficial it may be to the nation, will have a chance to see the light of the day unless it is found environment–friendly and socially viable. The author has done well to devote one full chapter exclusively on this aspect and has extensively referred to the guidelines drawn from World Bank publications. One of the greatest challenges to the future project managers, is to align their thinking with the social needs of the global society. More GDP will never be considered a good index for reflecting realistically the social and economic health of the country. Future projects will have to pave the way for alleviating poverty, generating massive employment, creating broad based purchasing power and raising the standard of living of the common man.

Dr. Joy's book on Project Management gives comprehensive treatment to the subject in the Indian context. It should serve as a good hand-book to Indian project managers.

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Accounting for Human Assets – Concepts, Systems and Practices: edited by D. Prabhakara Rao, Inter-India Publications, New Delhi, 1993, 272p, Rs. 340

The phraseology "Human Resources Development (HRD)" became popular in the UK when a Ministry of HRD was created there during 1970-71. India adopted this in the late eighties when Rajiv Gandhi was the PM. Industries/Govt. Organisations have to rely heavily on effective Human Resources Management (HRM) in terms of their recruitment, training, development etc. to achieve better results. But "Accounting of Human Resources" (HRA) i.e. employees in a Company's balance sheet is a new trend since 1968. The concept gained momentum in the USA since 1960. R.G. Barry Corporation in Ohio, Columbia, USA developed a model for accounting of its employees in 1967 and put it to use for managers only in 1968. The model was then extended to other employees of the Corporation. Like other physical assets, human resources were to be recognised as "assets" and shown accordingly in the balance sheet as "assets" and "liabilities" in an adopted format. The Committee on Human Resource Accounting (HRA) of the American Accounting Association (AAA) defined HRA as "the process of identifying and measuring data about HR and Communicating this information to interested parties". There are many similarities of "HR" with Physical Assets but only upto a point. India was quick to adopt HRA and a few giants amongst Public/Private sector companies had also introduced it in the seventies onwards.

The present volume comprises 18 papers and live case studies written by eminent Professors (including the Editor himself contributing a few papers/case studies) and professionals from Faculties in Commerce/Business Management of various Indian Universities/Institutions. The subject of accounting human assets has been systematically developed and explained right from initial concepts through their practical applications/case studies, not only in the USA but also in selected Indian Companies. Even a reader, not yet initiated to the subject, will find this book easy to read and understand. This shows that the contents of the book are edited and arranged very well. The keen reader will also find a list of relevant publications on HRA in the book for advanced studies.

The procedures evolved so far by the accounting professionals including Indian Accounting Association are far from simple and practical enough to encourage their ready acceptance. There are well reasoned arguments also against the cost-benefit aspects of HRA as men/women are not really like machines as yet. The accounting of the "Potential" of minds of employees is indeed a rather complex process and errors are likely! HRA has not to date made much headway in company balance sheets all over the world because of the above complex problems against the backdrop of traditional concepts of accounting we are familiar with. Realistic and yet simple with no errors accounting procedures will have to be evolved, may be with advanced psychology and Computer applications, to make HRA readily adoptable by Companies. To date Govt. rules do not make HRA compulsory or even "desirable". Accounting Standards Committee also makes it voluntary. In this connection, the 1993 UNDP Human Development Report with Dr. Mahbub-ul-Haq as its principal author is very relevant. It relegated India from 121st place in 1992 to 134th position in 1993, out of a total of 173 countries. Indian efforts and expenditure even to develop basic HR is rather low – $ 9 per person against S133 by even a country like S. Korea. This brings little credit to the HRD movement in India.

The implementation of HRA is in its infancy even after three decades. The case studies of companies doing HRA as shown in the book give an insight into the working of the system. However, these include only one American Company-Barry Corporation, that too for the initial years of 1969-73 only. Even Barry Corporation reported its HRA as a supplement to its annual reports. Quite a few Indian Companies are also practising HRA in different shades e.g. SAIL and BHEL reported HRA in their Annual Reports as additional information but not incorporating as assets and liabilities in the Balance Sheet. The details of the case studies of six Indian Companies in the book neither provide continuity of methodology being adopted nor the latest trends being followed as these reports of BHEL ('74-75, '78-79, '87-89 only), SAIL ('83-84 onwards), ACC ('85-86 only), HMTC '89-90 only) NTPC ("88-89 only) SPIC ('88-89 only) are probably for the years for which these informations were made available to the Editor at random. More disturbing, however, are the recent development that are putting HRA aside- even "Barrys" have discarded it from 1974 on the grounds of System Costs and resultant benefits. But in India more and more companies have introduced HRA. What is happening in other companies in the USA, Japan and other leading industrial countries have not been reported in this book. The reader has to look elsewhere.

HRA is relatively new to even many professionals. This book fills this gap to educate the reader and to stimulate his thoughts for further development. Herein lies the utility of this book for all teaching Institutes, Govt. Organisations as well as professionals, planners and policy makers. The book is attractive and a worthwhile addition to human knowledge. A later edition, should, however, provide uptodate state of HRA in various countries to make it more useful. Our Management Institutes should also introduce HRA in their curriculum for future managers.

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'Against the Wall – West Bengal Labour Scenario': Nagarik Mancha. Block B, Room – 7, 134 Raja Rajendralal Mitra Road, Calcutta-85, Spokesman, Calcutta, 1991, pp 74, Rs. 40

Nagarik Mancha (Citizen Forum), an information resource group based in West Bengal has brought out a detailed monograph on the conditions of labour in the modern industrial sector in West Bengal. Questions regarding the real earnings of workers, insensitivity of the government in tackling the problem of revision of minimum wages, transformation of the character and composition of workers engaged in modern industrial activity are some of the key issues discussed in the book. The background of the publication seems to be the silence in the annually released document of Government of West Bengal entitled "Labour in West Bengal" on the above mentioned aspects of labour scenario in the state.

The book is divided into ten chapters. In the first chapter, the classification of workers is made as formal and informal sectors, the latter including household and small non-registered industrial units and other agricultural and allied workers. There is also a discussion on the trends in the growth of wage workers over the period 1961-81, the wage level of the registered factory workers in the state and the level of productivity during the period. The table given at the end of the chapter is very illustrative – the number of workers involved and person days lost in strikes and lockout during (1965-90) shows that the number of lockouts are more than number of strikes in recent years.

The gravity of industrial sickness and its consequence to labour are very clearly brought out in the book. Apart from this, certain individual instances of poverty and sufferings of workers are given. Facts about the origin and growth of jute industry are discussed along with a brief description of the condition of domestic and international market for jute products. It is interesting to note that the internal competition of jute products is on the increase over the years and because of this the condition of top class jute manufacturers and traders has improved while the condition of labour in this industry has become more dismal. Though there is a legislative protection for minimum wages, since 1948, the authors point out that there are many loophols in 25 implementation out of 56 employments in the schedule of M.W. Act 1948, the minimum wages have been fixed only in 38 employments upto 1989. The authors have tried to find out the real cause of the closure of certain profit making cotton textile mills in West Bengal: The end of Textile Processing Corporation of India, is mainly due to the mismanagement of Industrial Reconstruction Bank of India (IRBI) as detailed in the book. In Kesoram Mills, a venture of Birlas, in the name of modernisation a good portion of workers were made redundant. In Sri Durga Mill the original proprietor had not spent a single paise for modernisation and replacement, eventhough there was a repeated demand from the employees to replace the 'dead' machine. The Dumber

Mill was closed down merely because of enbroilment in the family about internal property. As we move to the last part of the chapter, we understand that the crisis in cotton textile industry is not because of lack of demand but due to mismanagement and fallacies in the textile policy of the Government.

In chapter seven, the authors vehemently criticise certain new long term agreements reached between management and workers named "Memorandum of understanding". Many of these agreements stand in the way of the rights of employees – both statutory and non-statutory. But, the authors fail to give an adequate explanation on the background under which the management and Union entered in to such agreements. The authors on behalf of *Nagrik Mancha* have submitted a Memorandum to the Board for Industrial and Financial Re-construction (BIFR) recommending the participation of workers in the enquiry on sick industrial companies.

While concluding, the authors argue that the new worker in West Bengal is a second or third generation worker who respects collectivism and democracy. The relation between workers and trade Union leaders has become more professionalised in West Bengal, according to them. The high wage in certain industries have changed the lifestyle and consumption pattern of a group of workers.

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Economy Society and Development: Edited by C.T. Kurien, E.R. Prabhakar and S. Gopal. New Delhi, Sage Publications, 1991, 331 p.

The book under review is the outcome of the joint effort of the inspiration and encouragement by Prof. Malcolm S. Adiseshiah, editorial efforts of Professors C.T. Kurien, E.R. Prabhakar and S. Gopal and institutional support from the Madras Institute of Development Studies. In addition to a historical background regarding the contribution made by Prof. Adiseshiah and an introductory chapter, the book contains sixteen essays authored by very eminent scholars of the country. Although they appear rather heterogeneous without a unifying central theme, they have been classified into three broad categories – 'Economy', 'Development and Planning' and 'Education'. The introduction serves three purposes: unifying the theme around the personality of Prof. Malcolm S. Adiseshiah, weaving all the essays together and highlighting the main concern of each essay alongwith some experience-based academic comments.

K.N. Raj's observations in "Village India and its political economy" are based on the original study made by Gilbert Slater on the political economy of five villages in Tamil Nadu and three surveys made in 1937, 1961 and 1982. According to the author, there has been considerable economic growth and modernisation in the study area over the sixty years, but it has failed to significantly improve the standard of living of the masses. This is hardly surprising since the changes have taken place within the context of a prior distribution of the ownership of means of production and on the basis of the rules of the game that protect and reinforce the ownership structure. The implication of state intervention through public distribution system has been examined by R. Radhakrishna in his paper "Political Economy of Grain Market Intervention in India". Through a simulation exercise, he arrives at the conclusion that the scheme does not adversely affect either domestic output or aggregate consumption of rice though it affects producer and consumer prices. In response to the issue whether it is better to use public resources on welfare schemes or on productive operations, he argues that it is not always necessary to think of welfare measures and investment projects as alternatives. Barbara Hariss's piece also deals with some aspects of public interventions in the context of another state, Tamil Nadu. She deals with three interventions – public distribution, the noon meal scheme and the tax on alcohal.

A. Vaidyanathan point out that the neglect of dry land or more appropriately rainfed agriculture is the most important aspect which can be held responsible for the slow growth of agriculture. Further, he says that the attempt has been far too much on physical investment to the neglect of developing institutional mechanisms to get groups of farms/villages to accept and to enforce essential changes in the way land is used and managed. Nadkarni in his essay, "Economics and Ecological Concern", points out that the economists' preoccupation is with prices and costs as they are revealed through market processes and ecological aspects do not have a direct bearing on market transactions. That is why ecological problems have not received the attention they deserve from economists. In the essay, "Limitations of the concept of National Income as a measure of National Prosperity." V.K.R.V. Rao indicates that at best national income is the money value of goods and services produces in a country within a given period, whereas national welfare is a matter of psychological pleasure or satisfaction.

K.S. Krishnaswamy touches two strands in Indian Planning–one with built-in tendencies towards centralisation and the other, with a clear emphasis on decentralisation. One of the major problems in our country, according to the author, is how these twin tendencies pulling in opposite directions can be operationally coordinated. He admits that the major risk is that in the rural areas, the rich and powerful section can easily hijack the bulk of the resources as also the administrative machinery itself to serve their purpose. He suggests various steps to counter and neutralise such tendencies. Gulati argues that the allocation of funds between the Union and the states is not adequately governed by statutory provisions and is dominated by adhocism and the consequent arbitrariness in favour of the Union Government. Parthasarathy's paper on Rural Development compares the evaluation of poverty alleviation programmes of the early 1980s and the late 1980s and points out that the more recent studies are less discomforting about the performances and possibilities of these programmes. Leakages have been reduced and assets obtained by the poor tend to stay with them. He is doubtful whether the thrust of these micro-programmes is compatible with the macro tendencies dominating the economic scene. L.C. Jain in the paper "The Role of Traditional Industries in India's Development" also points out the conflicting character of the Policy Frame. According to him Mahalanabis strategy assigned an interim status to the traditional handloom industries. A logical requirement of that strategy would have been a clearly worked out programme of action to phase out the extremely low level of techniques and to upgrade the ones that can be so modernised and to provide for their constant technological improvement by linking them up with other sectors of the economy so that labour productivity continuously increase. There has been very little of such programmes and in the absence of such a positive approach the tragedy that Jain has indicated would continue with the temporary issues turning out to be something of a permanent settlement. Amulya Reddy in his paper on 'Development of Energy and Environment in India' says that there is a growing conflict in India between the lobbies of economic growth and the movements of environmental protection to determine which should decide the fate of the country. According to him, the conflict can be resolved by adopting an integrated view point in our planning. While assessing the performance of Indian Planning, D.T. Lakadwala concludes that a growth rate of 3.6 per cent per annum between 1950-51 to 1987-88 may have been somewhat disappointing, in terms of expectations but tremendous success with best performance. Even in terms of social justice, there have been noteworthy achievements though the record cannot be considered to be as commendable as in the sphere of growth. He highlights the shortcomings of the concept of poverty line and stress that other items – education, health etc., should also be taken into consideration while defining poverty line. M.S. Gore argues that a measure of economic equality and secularism is the social content of democracy without which it will be reduced to an empty shell which cannot last for long. He argues that social problems might be intense and acute but they would be non-problem if they do not have direct bearing on the political processing of the times.

The last three essays in the book are concerned with education. Bhabatosh Datta presents the change in the teaching of economics in the country. Data points out the dichotomy between textbook theory of economics on the one hand and the live problems of Indian economy on the other. In later stages, the gap between the teaching of economic theory and of Indian problems has been reduced considerably. In these days, with rare exceptions, teaching and research do not go together to the deteriment of both. V.C. Kulandaiswamy says that the present education system is universaly condemned has an average growth rate of about 5 per cent in institutions during the last five years. We see the paradox of condemning a system and expanding it mechanically. Sylvain Lourie looks at the education system from the angle of its demand and supply and concludes that as there is no linear casual link between these two forces and they meet solely by a confluence of factors, the result is synergy, rather than a logical predictable construct

The essays included in the book cover almost all aspects of planning and its impact on macro as well as micro levels. Having covered such a vast subject, the book may prove very useful for integrated research work.

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India's External Debt: From Self-reliance to Dependency

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The purpose of this paper is to outline the changing profile of India's external debt and to argue that India's planning is slowly moving away from the goal of self-reliance towards dependency.

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Before Independence Indian economy was dominated by the metropolitan capital. Indian business was vehemently hostile to foreign capital. FICCI wanted to repatriate British Investments in India using "our accumulated (sterling) balances". G.D. Birla, speaking for Indian capital as a whole, echoed this sentiment strongly on several occasions (Kidron, 1965). The fifteen year plan drawn by the Bombay businessmen in 1944 envisaged a great role for public sector and wanted to build a strong indigenous base.

Quite understandably the young nation which was a creditor with an accumulated sterling balance of 1.2 billion in sterling securities in 1948 was keen to safeguard her independence by building economic strength. The Nehru-Mahalanobis strategy that India adopted in the post-colonial era was strongly governed by considerations of self-reliance.

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The goal of self-reliance set before the nation had a clear rationale. It definitely was not governed by a negative rationale of the so-called export pessimism as is asserted by many economists, (Ahluwalia, 1992; Jalan, 1991, for instance but was one of building the economic prowess and competitive strength of the country by investing in 'mother' industries. Protecting the indigenous industries to foster their competitive strength and innovative capabilities (rather than imitation of technology) was very much on the agenda. Promoting the home-market through employment generation, and widening the asset base and other measures to build the purchasing power of the masses were also parts of the strategy. The intent clearly was to have an investment and commodity mix with priority for mass consumption goods rather than high 'techs' needed for the affluent sections. Thus, given the focus of catering to the needs of the people of the country there was a stress on home market rather than on export. Export-led growth was not the accent of the development strategy of the early years.

Undermining self-reliance

What happened in India during the last three decades has been a systematic undermining of the goal of self-reliance. The Government of India, the Indian business community, the multi-lateral lending institutions and agencies working in tandem with transnational capital – all have contributed to this process. We have come all the way from the 'inward-looking' strategy of industrialisation to open door free trade-based industrialisation. In this paper we do not propose to go into the factors leading to this transformation. However, we try to show that India has fallen into a debt trap, a situation of dependency indeed far removed from the goal of self-reliance with which we started our planned development.

We try to show that India has fallen into a debt trap, a situation of dependency indeed far removed from the goal of self-reliance with which we started our planned development.

Neither the big powers of the West nor the World Bank and the IMF took India kindly for the autonomous development path she has chosen to pursue. The two-men team from the World Bank (called McKittrick Mission after the name of the Chairman) which visited India in 1956 held that India was embarking on an "over ambitious" and "unrealistic" plan of developing public sector and pleaded for more space for foreign direct investment (FDI) and private sector. Eugene Black, the then President of World Bank wrote to the Indian Finance Minister impressing upon the need to follow the recommendations[1] (Hanson, 1966; Payer, 1974). The Second World Bank Mission of 1958 repeated almost the same criticisms when the foreign exchange crisis worsened (although the withdrawal from the IMF still did not exceed the upper credit tranche).[2] Without further cataloguing or documentation one can safely maintain that the message that has been sent out persistently from the corridors of IMF, World Bank and USA was that the economic regime of self-reliance being built up in India based on protectionism, large state sector investment, controls upon private sector and foreign capital should be dismantled. It may be noted at the outset this has happened long before the regime had been given a fair and proper trial.

Aid India Consortium

The World Bank early enough came forward with a great gesture of help in creating the Aid India Consortium in 1958 originally comprising Canada, Japan, Britain, West Germany and USA, countries in which India had placed most of its orders for Second Plan Projects.[3] However, we may have to remember that the members are not altruistic aid-givers, but governments interested in seeing that the countries which provide markets for their products do not collapse completely or withdraw from the capitalist trade system (Payer, 1974, 171). An era of reliance on external assistance through Aid India Consortium led by the World Bank has commenced.

The crisis of the Second Plan proceeded almost unabated with the sterling balances fully depleted and important requirements kept mounting up. The hostilities with China (1962) and Pakistan (1965) with their tremendous foreign exchange costs worsened the situation. All these coincided with two years of severe droughts which drove India from the frying pan into the fire as that led to heavy food imports and severe drop in export earnings. Under such a situation the Aid-donors under World Bank (virtually led by U.S. government) could dictate their terms. Following the recommendations of the Bell Mission in 1964 (A World Bank Mission headed by Bernard Bell), the Aid India Consortium insisted on a devaluation of the rupee, with the usual conditionalities such as dismantling of controls, abolition of export subsidies and so on. Despite brave pronouncements to the contrary, India devalued the rupee by 36% in June 1966 and initiated steps on the lines of the recommendations of the Bell Mission. This is a clear departure from the industrialisation strategy that India adopted as part of her planning,

[1] Apparently the Finance Minister, T.T. Krishnamachari did not quite appreciate the letter of the World Bank President and gave a reply reiterating India's avowed goals.

[2] There is no conditionality to withdraw 25 percent of a country's quota from the IMF called the reserve tranche or gold tranche. Real conditionalities come when withdrawals above 50 percent of quota or upper credit tranche is resorted to.

[3] In 1961 France and the newly formed IDA and in 1962 Austria, Belgium, Italy and the Netherlands and in 1968, Denmark became its members.

the basic objective of which was progressive minimisation of dependence on foreign markets and building India's competitive strength in world market by promoting indigenous industries as we have already noted.

It is now widely known that devaluation did not produce the expected results. Nay, the situation only worsened as the export pick up was poor and the growing imports under the liberalised licensing had to be paid for in larger amounts of foreign exchange. Though a substantial aid ($ 900 million) was promised prior to devaluation only a little over half ($ 465 million) was given by the various member governments of the Consortium. India in fact, had to recourse to an era of plan holidays for three years in succession. India's external debt stock which was a negligible sum of less than $ 80 million in March 1951 rose to $ 7.93 billion in 1970 when the Fourth Plan was launched with a renewed emphasis on self-reliance.

Closing the Trade Gap

By and large, most part of 1970s (1979-80 being a remarkable exception) saw a trend that was in significant contrast to the period of the first two decades of planning. For the first time since planning began the trade deficit has been narrowed down and made into a surplus at least for a couple of years. This is illustrated in Figure-1 which show the export-import trade gap in dollar values. The diagram illustrates the clear contrast with the experience of the 1980s as well. Not only that the net aid inflow was very low during the 1970s, the foreign exchange reserves also started building up from a low of $ 584 million in 1970-71 to $ 6.42 billion in 1978-79, (eleven times increase in 9 years time), the highest recorded figure during the 42 years from 1951 to 1992. This build up was made possible largely through the better performance of invisibles, notably the sharp spurt in foreign remittances shown in Figure 2 which in no small measure was due to the oil-boom induced developments in Gulf countries which attracted manpower from Indian States like Kerala. The adverse impact of the first oil shock of 1973-74 has thus been turned into a current account surplus for several years during 1970s. Even in 1979-80 with the onset of the second oil shock when international oil prices almost trebled, the foreign exchange reserves was still $ 6.32 billion though it quickly started sliding down since then. The trade gap widened and current account balance deteriorated not only because of the oil price hike but also due to large imports of food grains, edible oils and fertilizers caused by supply shortages as well. The Government of India responded to the situation by going in for a massive IMF loan of the EFF (Extended Fund Facility) variety for SDR 5 billion in 1981.

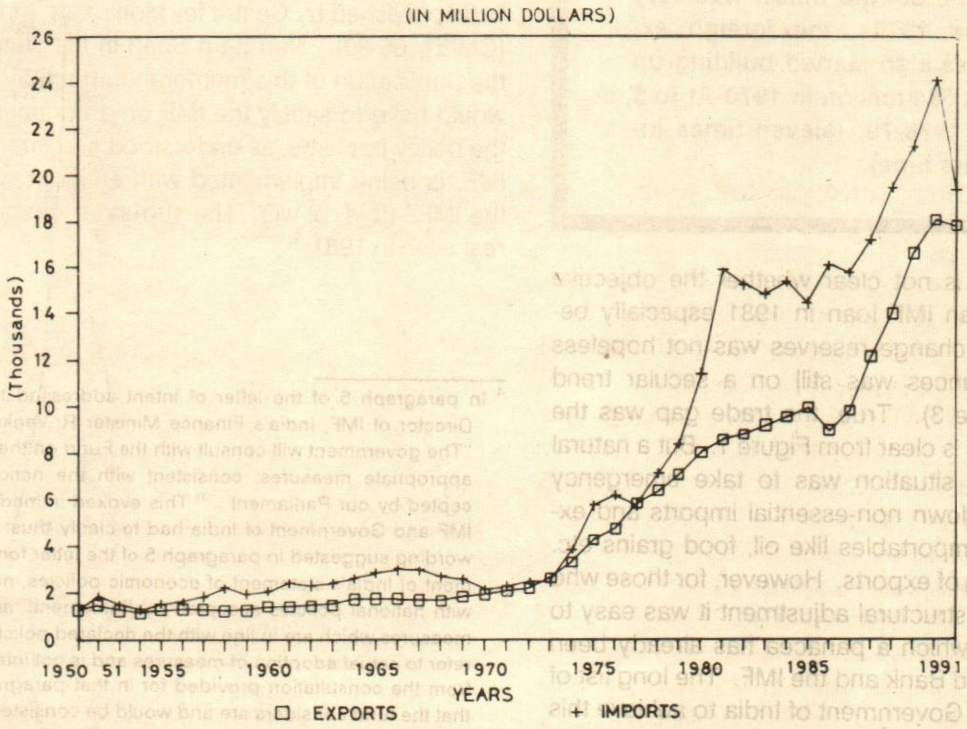

Fig. 1 Exports and Imports (Based on Govt. of India Economic Survey 1992-93 Table S.85)

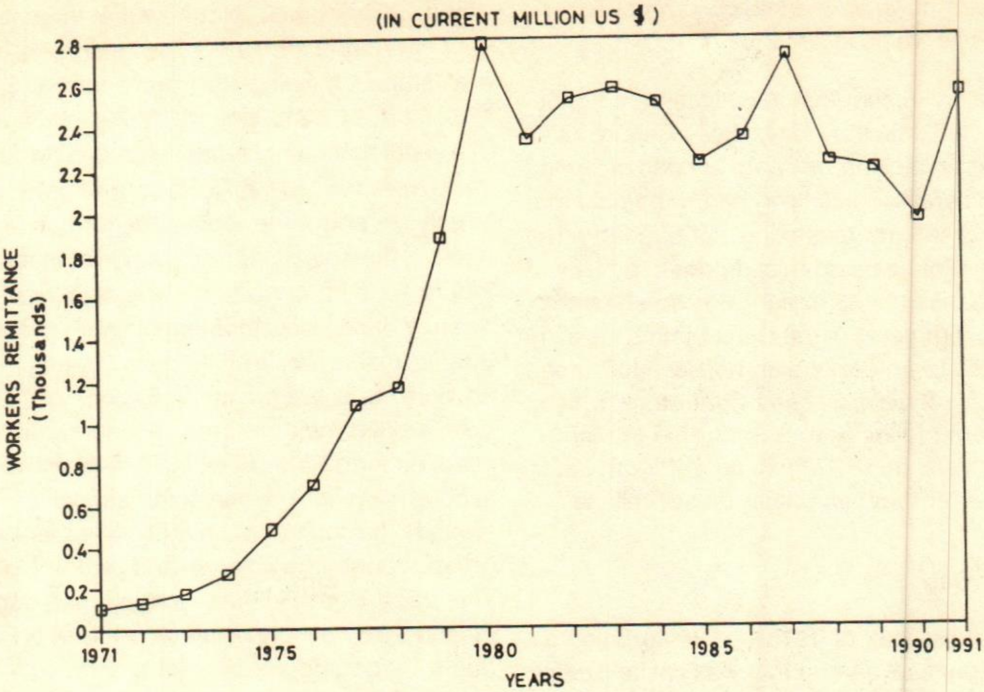

Fig. 2 Workers Remittances

> **Not only that the net aid inflow was very low during the 1970s, the foreign exchange reserves also started building up from a low of $ 584 million in 1970-71 to $ 6.42 billion in 1978-79, (eleven times increase in 9 years time).**

Looking back it is not clear whether the objective situation warranted an IMF loan in 1981 especially because the foreign exchange reserves was not hopeless and the Gulf remittances was still on a secular trend (projections in Figure 3). True, the trade gap was the highest in 1979-80 as is clear from Figure 1. But a natural response to such a situation was to take emergency measures to prune down non-essential imports and expand the supply of importables like oil, food grains etc. along with promotion of exports. However, for those who wanted to introduce structural adjustment it was easy to project a 'crisis' for which a panacea has already been patented by the World Bank and the IMF. The long list of measures agreed by Government of India to achieve this goal was contained in the statement of economic policies attached to the Government of India's application for IMF loan in 1981. (See "Secret" IMF Memorandum on Loan to India published by Centre for Monitoring Indian Economy [CMIE], 66-80). Narottam Shah in his "Introduction" to the publication of this memorandum rightly notes: "India would have to satisfy the IMF on a continuing basis that the policy package, as understood and interpreted by the IMF, is being implemented with a vigour which satisfies the IMF" (Ibid, p. viii). The surrender of sovereignty was real even in 1981.[4]

[4] In paragraph 5 of the letter of intent addressed to the Managing Director of IMF, India's Finance Minister R. Venkataraman noted: "The government will consult with the Fund on the adoption of any appropriate measures, consistent with the national policies accepted by our Parliament ..." This evoked immediate protest from IMF and Government of India had to clarify thus: "The additional wording suggested in paragraph 5 of the letter forwarding Government of India's statement of economic policies, namely consistent with national policies accepted by Parliament" and "Government measures which are in line with the declared policies" are meant to refer to actual adoption of measures and is not intended to exclude from the consultation provided for in that paragraph any policies that the fund considers are and would be consistent with achieving the objectives of the programme" (Ibid, 65-66).

Table 1: An Index of Dependency

Years	GDP (Rs.) Crores	1$ = Rs.	GDP $ millions	External Debt million $	External Debt as % GDP	Total Debt Service million $	Total Debt Service as % GDP	Index	Dependency Index 1980 = 100
1	2	3	4	5	6	7	8	9	10
End March 1980	114356	7.89	144937.8	20611	14.22	1407	0.970760	15.19	100.00
1981	136013	8.93	152310.1	22638	14.86	1519	0.997306	15.86	104.40
1982	159760	9.63	165898.2	27471	16.56	2042	1.230875	17.78	117.10
1983	178123	10.31	172775.9	32035	18.54	2563	1.483424	20.02	131.81
1984	207589	11.89	174591.2	33859	19.39	2938	1.682787	21.07	138.73
1985	231343	12.24	189005.7	41021	21.70	3534	1.869784	23.57	155.17
1986	262243	12.79	205037.5	48354	23.58	5274	2.572212	26.15	172.17
1987	292949	12.97	225866.6	55825	24.72	5693	2.520514	27.23	179.28
1988	333201	14.48	230111.1	58467	25.41	6310	2.742152	28.15	185.30
1989	396593	16.66	238051.0	63929	26.86	6482	2.722945	29.57	194.70
1990	453986	17.95	252916.9	69139	27.34	7027	2.778381	30.11	198.23
1991	530865	24.52	216502.8	71557	33.05	7445	3.438753	36.49	240.20

Source: Data for Column 2 is taken from Government of India (1993) *Economic Survey* and 3, 5 and 7 are from World Bank's World Tables 1993 and World Debt Tables 1992-93.

Note: Dependency ratio = (Total External Debt + Total Debt Service)/GDP * 100

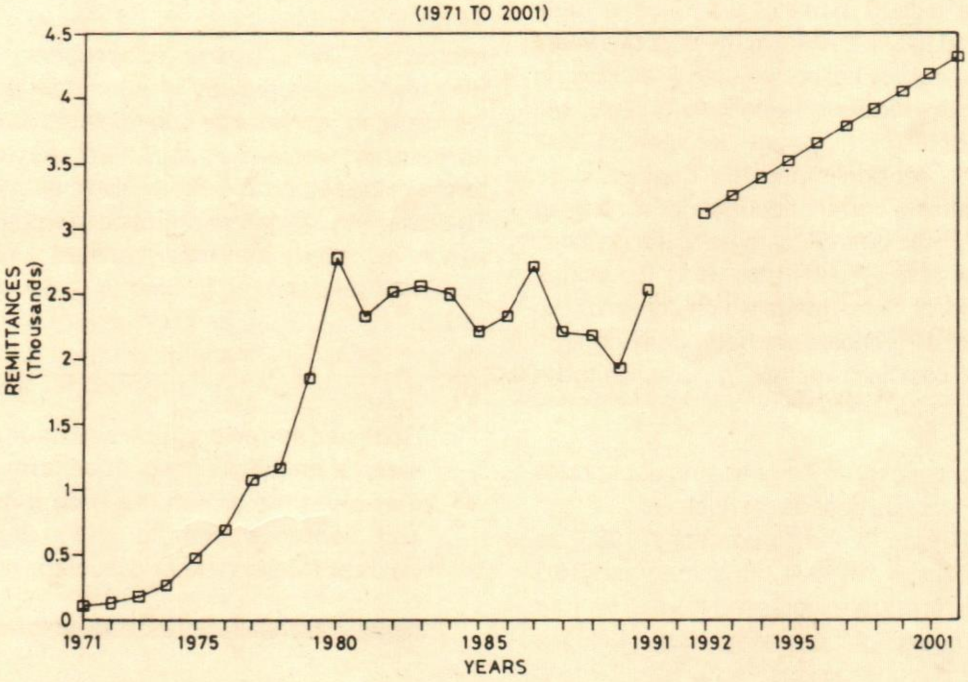

Fig. 3 Workers' Remittances Projections (Projections are made using linear trend regression of the simple $y = a + bx$ form)

External Debt (EDT)

An important aspect of the problem is that a substantial portion of the large current account deficit that progressively swelled up during the 1980s has come to be financed by capital inflows. Tables 1 and 2 are meant to highlight this. It may be noted from table 1 that the total external debt (EDT) outstanding increased from $ 20.6 billion in 1980 to $ 71.6 billion in 1991. In terms of GDP ratio, it was a growth from over 14 percent to 33 per cent. If we go by the Government of India's figure for 1991

Table 2: Debt Service, Disbursement and Net Transfers 1980-1991

(in million US $)

Year	Disbursements	Total Debt Services (TDS) (Amortisation + Interests)	Total Debt Service as % of Disbursement
1980	3203	1407	44.0
1982	4871	2042	42.0
1983	4366	2563	59.0
1984	3959	2938	74.0
1985	3850	3534	92.0
1986	5210	5274	101.2
1987	5823	5693	98.0
1988	6299	6310	101.2
1989	5891	6482	110.0
1990	6924	7027	101.5

(Government of India, 1993, 3) which includes the defence debt, EDT goes to $ 81.9 billion and debt-GDP ratio shoots upto 37.8 percent. The increase in debt to private creditors (including transnational commercial banks and non-resident Indians) which was a negligible sum of $ 430 million in 1970 rose to $ 2.3 billion in 1980, which almost doubled to $ 4.3 billion in the next two years time (1982) and dramatically ballooned upto $ 25 billion in 1989 though it slightly declined the following year. (All data from World debt tables). Though commercial bank borrowings, transnational banks and NRI deposits were not significant in financing current account deficits during early 1980s, they financed over 55 percent of the deficit in 1989 and in the year of the Gulf Crisis (1990) the shares rose even to 61 percent. These funds which come to take advantage of interest differentials are hot money or flight capital which are at best fair weather friends, not to be trusted upon in real crises.

Another important aspect of the changing debt profile is that the share of concessional debt which was as high as 87 percent of EDT in 1970 and 75 percent in 1980, fell to less than 42 percent in 1991. At the same time IBRD credit with variable interest rate increased from a low four percent in 1980 to nearly 12 percent in 1991. Bilateral loans (which are mostly of a concessional nature) which formed over 50 percent of debt stock in 1980 fell to around

A substantial portion of the large current account deficit that progressively swelled up during the 1980s has come to be financed by capital inflows.

22 percent in 1990 and 1991. (All the figures based on World Debt Tables, 1992-93). Probably the most important factor is that all the terms of borrowing such as interest rate, maturity period, grace period and grant component have turned against India. The average interest rate of private creditors was as high as 8.7 percent and maturity period 7.7 years in 1991.

All the terms of borrowing such as interest rate, maturity period, grace period and grant component have turned against India.

Debt per se for a country cannot be considered an evil in itself. It becomes a burden when the nation falls into a debt trap and becomes pathologically dependent on debt for survival and growth.

A country may be said to be in a debt trap when the total debt services (TDS) exceed the gross disbursements flowing into a country. It means a reverse flow of resources. This is a strong dependency syndrome and becomes a deep malady when certain objective factors like growing incremental additions to the debt stock, the consequent increase in total debt services, worsening terms of trade and the like register an increasing trend. The following indicators are chosen to gauge India's dependency syndrome: net transfers, EDT/GDP ratio, TDS/GDP ratio, and EDT/exports of goods and services (XGS).

Debt per se for a country cannot be considered an evil in itself. It becomes a burden when the nation falls into a debt trap and becomes pathologically dependent on debt for survival and growth.

It is clear from table 2 and Fig. 4 that the net transfers which is but the difference between disbursements and total debt services have turned negative. Disbursements show a country's drawing on loan commitments during the year specified and TDS shows the repayments of principal and interest. Figure 4 shows that the disbursements curve and TDS curve cut each other in 1986. Thus long before the so called crisis of 1991, India had fallen into a debt trap. More disquieting is the latest report from

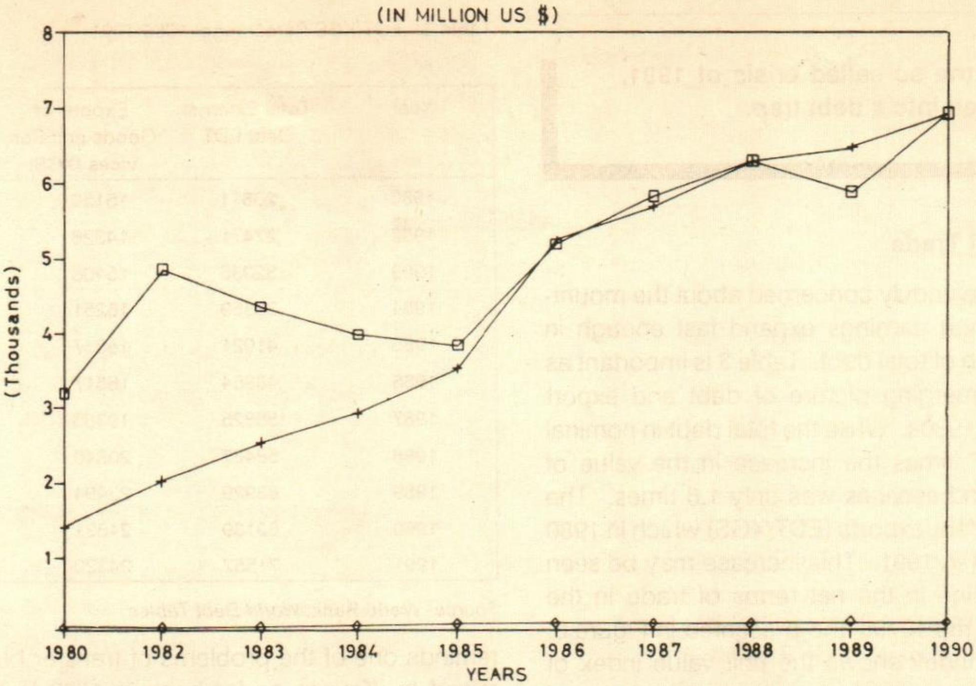

Fig. 4 Debt Services and Disbursements (1980-90)

the Government of India's monthly report for November 1993 which shows that net transfers abroad in 1992 was Rs. 814 crores. TDS was Rs. 4166 and gross disbursements Rs. 3352 crores) and the net outflow for the first 6 months was Rs. 1676 crores or more than double that for the previous year as a whole.

Table 1 shows the percentage of EDT to GDP and TDS to GDP during the 1980s. Combining these two variables we have worked out a simple index which we have chosen to call a dependency index. The dependency index (Figure 5) shows a very sharp secular trend during the 1980s.

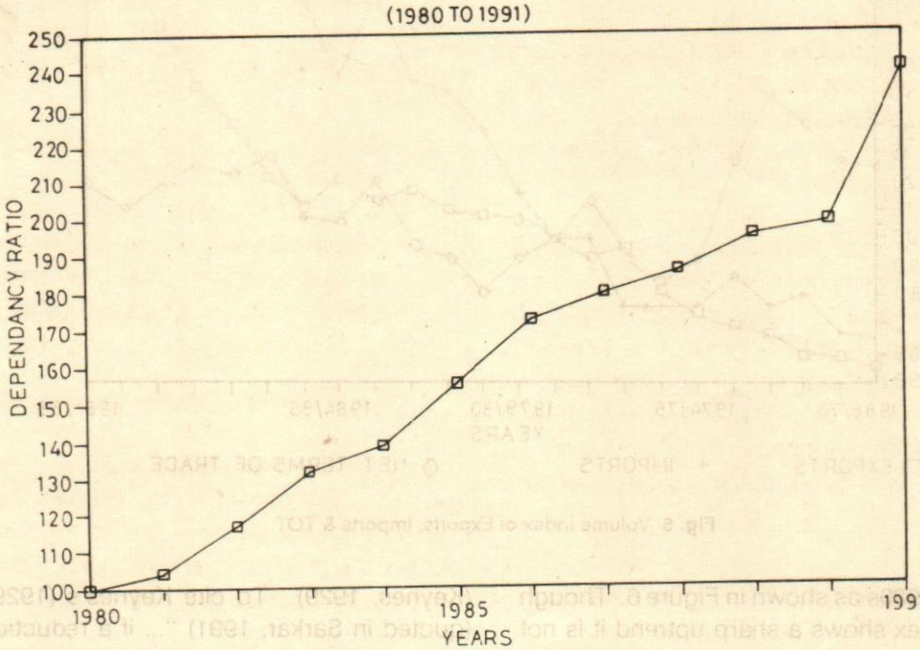

Fig. 5 External Dependancy Index

Long before the so called crisis of 1991, India had fallen into a debt trap.

Declining Terms of Trade

One need not be unduly concerned about the mounting debt; if the export earnings expand fast enough in relation to the growth of total debt. Table 3 is important as it brings out the emerging picture of debt and export earnings during the 1980s. While the total debt in nominal terms increased 3.5 times the increase in the value of exports of goods and services was only 1.6 times. The percentage of total debt/exports (EDT/XGS) which in 1980 was 136 rose to 294 in 1991. This increase may be seen along with the decline in the net terms of trade in the 1980s compared to the 1970s and presented in Figure 6. Net terms of trade index shows the unit value index of exports expressed as a percentage of unit value index of imports. There is a dramatic increase in the volume index of imports during the 1980s as shown in Figure 6. Though the export volume index shows a sharp uptrend it is not adequate or fast enough to buy our imports. The decline in terms of trade is a matter of serious concern and reminds one of the problems of transfer burden of debts raised by Keynes as far back in 1929 in the context of German reparation payments after the First World War (Keynes, 1929). To cite Keynes's (1929) own example (quoted in Sarkar, 1991) "... if a reduction in price of 10 percent stimulates the volume of trade by 20 percent, this does not increase the value of the exports by 20 percent,

Table 3: EDT/XGS Percentage: 1980-1991

(in million US $)

Year	Total External Debt EDT	Exports of Goods and Services (XGS)	EDT/XGS (Percentage)
1980	20611	15150	136.0
1982	27471	14326	191.8
1983	32035	15406	207.9
1984	33859	16251	209.5
1985	41021	15537	264.0
1986	48354	16517	292.8
1987	55825	19385	288.0
1988	58467	20840	280.6
1989	63929	23494	272.1
1990	69139	24831	278.4
1991	71557	24320	294.2

Source: World Bank, *World Debt Tables*.

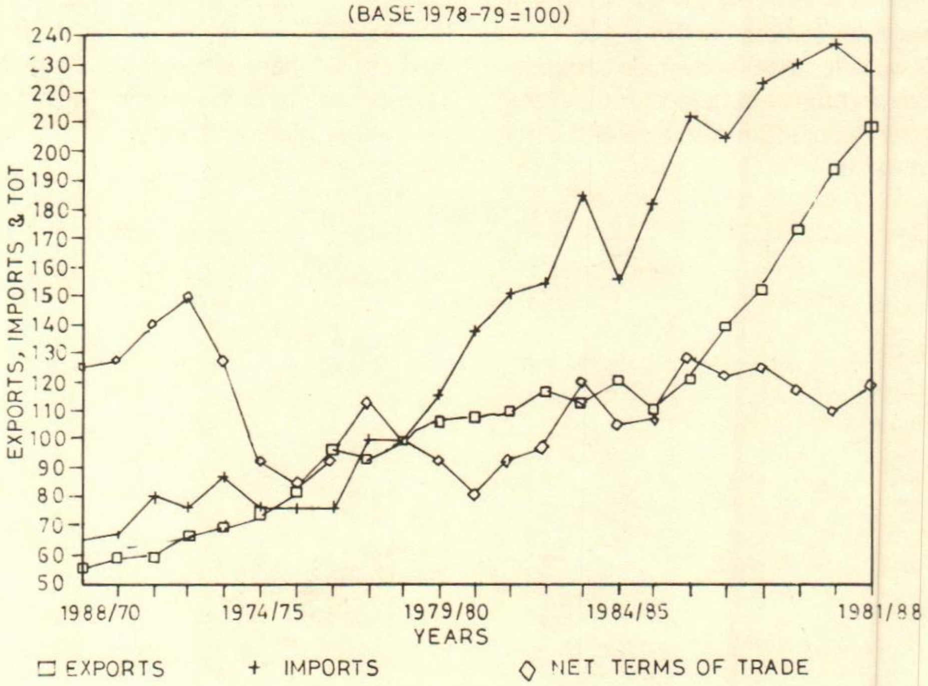

Fig. 6 Volume Index of Exports, Imports & TOT

but only by 8 percent ($1.20 \times 90 = 108$)". This is a real problem which has to be faced and the evidences adduced by Sarkar (1991) regarding LDCs like India cannot be ignored except at our peril.[5]

> **Larger exports have to be bartered for a unit of imports.**

Conclusion

In sum, the analysis above has indicated the evolution of a foreign exchange crisis into a debt crisis over the years. In the 1980s the net transfers to the creditors have turned positive and substantial. This is of a greater significance in view of the fact that larger exports have to be bartered for a unit of imports reminding one of the Fisher Paradox with its ominous consequences. The road from self-reliance to dependency seems to be shorter and smoother than anticipated. One aspect that needs to be made explicit relates to the technological gap and dependence that keep increasing along with this. It is clear that we have not used our growing imports to build our competitive strength. In this context, it is not wide of the mark to quote rather elaborately the findings of a scientific study: "Even though India has been importing from abroad, so much so that its large imports bill has made India one of the few major debtor countries of the world, yet India has not been able to use these imports to build its production and export potential. Liberalisation policies of Rajiv Gandhi did not create such a potential. The World Bank and IMF dictated policies are rarely helpful. Loans from these institutions and the implied conditionality, raise costs in the present with a doubtful benefit if any in the future. Strange as it may seem these days, the road to competitiveness does not follow from liberalisation policies. On the contrary, it follows from policies of 'Swadeshi', where imports are used for 'self-reliance', as the experience and success of Far Eastern Economies confirm. Without the development of such competitiveness, free trade degenerates into creating more debt, dependence and eventually a depressed economy" (Diwan & Chakraborty, 1993, 2481). If the foreign exchange crisis was precipitated by a poor credit rating which in turn affect our loan facilities, paradoxically the increasing debt itself will be going to be the greatest threat to credit rating – a vicious circle indeed.

> **Without the development of such competitiveness, free trade degenerates into creating more dent, dependence and eventually a depressed economy.**

[5] Sarkar (1991) assembles some evidence to show that LDCs expanded their export volumes (which includes not only primary products but also manufactures) and faced losses in their export unit values in the process of their debt repayments and tries to show that at least some debtor countries encounter almost the 'insoluble' transfer problem posed by Keynes as they are facing the so-called Fisher's Paradox: The more the debtors pay, the more they owe.

References

Ahluwalia, Isher Judge (1992), "Structural Adjustment and Productivity Growth in India", Productivity, July-Sept.

Jalan, Bimal (1991) India's Economic Crisis, Oxford University Press, Delhi.

Kidron Michael, (1965), Foreign Investments in India. Oxford University Press.

Hanson A.H. (1966), The Process of Planning: A Study of India's Five-Year Plans 1950-1964, Oxford University Press.

Payer Cheryl (1974), The Debt Trap, Monthly Review Press.

IMF Secretariat, (1982), "Secret" IMF Memorandum on Loans to India, reproduced by CMIF, Bombay.

Keynes J.M. (1929), "The German Transfer Problem" Economic Journal Vol. 39.

Sarkar Prabirjit, (1991) "Debt Crisis of the less developed countries and the transfer debate once again", The Journal of Development Studies Vol. 27, No. 4 July 1991.

Diwan Romesh & Chakraborty Chandana (1993) "Is India's Economy Competitive", Economic and Political Weekly, November 6, 1993.

World Bank, World Debt Tables. (1992-93)

Government of India (1993), Indias External Debt: A Status Report, Ministry of Finance, New Delhi. □

The (Un) Making of a (Non) Competitive Economy

Padmini Swaminathan

Restoring dynamism and imparting competitiveness to the economy is a two-pronged affair, necessitating organizational changes both at the firm level and at the economy level. These need to be pursued simultaneously. While there is need to differentiate between the success (failure) of firms and the success (failure) of nation states, the character of the state-capital linkage in any economy is a crucial determinant of economic performance; hence the need to focus on strengthening the capacity of the state rather than on insulation.

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The accent of the recent developments in the industrial policy of the country, particularly the 'opening up' of the domestic industrial sector to global competition, has been in the government's own words, to "build on the gains already made, correct the distortions or weaknesses that may have crept in, maintain a sustained growth in productivity and gainful employment and attain international competitiveness" (Economic Times, 1991).

The obvious evidence of poor performance of the economy coupled with the pervasive phenomenon of rent seeking (corruption in common parlance) is largely responsible for the antipathy that has developed towards state intervention culminating in the announcement of the new policy statement. The latter privileges the market as the prime mover of development. Viewed differently, the increasing attempt of the 'liberalization' measures is to insulate the functioning of the industrial sector from political pressures on the assumption that, in the absence of intervention, the market itself will ensure economically correct decisions and that such decisions are sufficient for successful stabilization and adjustment.

The argument this paper hopes to develop is that, restoring dynamism and imparting competitiveness to the economy is a two-pronged affair (necessitating organizational changes at both the firm and economy levels), which needs to be pursued simultaneously and in which process the role of the state and firm is central. While there is need to differentiate between the success (failure) of firms and the success (failure) of nation states, the character of the state-capital linkage in any economy (that is the phenomenon of "embededness" characterizing the economy) is a crucial determinant of economic performance (Granovetter, 1985).

States Role in Technical Development

The imperativeness of state intervention in economic development, particularly industrial development, has formed the theme of much development literature. All third world states have attempted to accelerate economic development through growth strategies, which however, exhibit substantial variation in content, form, degree of commitment – across countries, instruments of implementation and over time. In the context of late industrializers, the analyses offered by Gerschenkron (1962) and Hirschman (1958) are still very pertinent and help to refocus attention on the centrality of the state despite neo-utilitarian attempts to reduce the state's role to the minimum.

Gerschenkron's main proposition is that, processes of industrialization are not amenable to implantation in backward countries. It is not just the speed of development that is problematic but the whole gamut of productive, organizational and financial structures of industry by means of which development took place in the advanced countries in the first place. These differences in the speed and character of industrial development are, to a considerable extent, the result of application of institutional instruments for which there is little or no counterpart in countries that began their industrialization earlier. Thus in late industrializing countries, it is not enough to simply provide a suitable environment; the state has to, in addition, organize crucial aspects of the market such as in the area of risk taking, serve as surrogate entrepreneur etc.

It is not enough to simply provide a suitable environment; the state has to, in addition, organize crucial aspects of the market such as in the area of risk taking, serve as surrogate entrepreneur etc.

Hirschman develops on the theme of 'inadequate' and 'timid' entrepreneurship characterizing the 'late late' developers of the 20th century third world. What is lacking in developing countries, according to Hirschman, is entrepreneurship in the sense of willingness to risk the available surplus by investing it in productive activities. If "maximising induced decision-making" is the key as Hirschaman argues it is, then the state's role involves a high level of responsiveness to private capital. The state must provide disequilibrating incentives to induce private capitalists to invest and at the same time be ready to alleviate bottlenecks that are creating disincentives to investment. States that undertake the tasks outlined by Gerschenkron and Hirschman are called 'developmental' by Evans (1992). "They (developmental states) extract surplus but they also provide collective goods. They foster long-term entrepreneurial perspectives among private elites by increasing incentives to engage in transformative investments and lowering the risks involved in such investments. They may not be immune to rent-seeking or to using some of the social surplus for the ends of incumbents and their friends rather than those of the citizenry as a whole. Yet, on balance, the consequences of their actions promote rather than impede economic adjustment and structural transformation." (Evans, 1992, p. 148)

However, argues Evans, the potential existence of a positive state role creates no logical necessity of the potential being realized, inasmuch as, societies and economies that need 'developmental' states do not necessarily get them. The acid test for the state arises when faced with structural transformation, which in turn, renders the state either into a predatory one or a developmental one.

There is no disputing the fact that the economic success of the major East Asian Newly Industrialised Countries (NICs) was/is premised on the active involvement of the state. These states could not only foster rapid local industrialization but also obtain effective adjustment to changing international markets. The difference between India and the East Asian NICs lies precisely in the less developmental (more predatory) nature of the Indian state as against the more developmental (less predatory) nature of the East Asian NICs.

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Import Substitution Policy

A substantive thrust of India's technology import policy has been the encouragement of domestic production to substitute for imports implemented through import-substitution industrialization. This in turn necessitated protection of domestic industry under the infant-industry argument. The manner of implementation and operationalization of this strategy in India has led to two major negative results (Unger, 1988, p 480-495). One is non competitive environment; the other is the continued dependence of the economy on imports of production goods with substantial underutilization of capacity of the same at home. Given the inefficiency of final goods industries and hence their inability to compete in external markets through exports, a limit to the import capacity of production goods has appeared as a result of foreign exchange constraints. The net result has been a stagnant, inefficient and non-integrated industrial sector.

The examination of such results needs to be done in a more rigorous manner than adopting the conventional argument of market inefficiency. One crucial thread of analysis revolves around the way in which technological change has been/was incorporated into and determined the industrial structure during the process of import substitution industrialization.

An interesting hypothesis that has been put forward with reference to the South Korean industries is that the latter's superior performance can be attributed to a combination of selective infant industry protection and export activity (Fransman 1985). Thus it is argued that the protection of infant industries is most effective not as a part of import-substitution regime but rather under an export-oriented one. Several reasons have been put forward to account for the positive effects that exports may have on total factor productivity, namely: "the competitive pressure that compel improvement in product quality and reduction in cost; opportunities for international inter-firm learning that are opened up by exporting activities; economies of scale due to increased market size as a result of exporting possibilities and also fall in costs; overall improvement in productivity due to greater availability of foreign exchange and more productive inputs." (Fransman, 1985, p 620-621).

South Korean industry's superior performance can be attributed to a combination of selective infant industry protection and export activity.

Underlying this beneficial positive association between economic performance and exports is an implicit assumption; the attainment of a minimum threshold level of technological capability which can only be built up during a prior period of protected import substitution. The central role played by the domestic market in the growth of countries like South Korea and Japan has also been emphasized (Nishimizu & Robinson, 1983).

However, in each of the above the precise causal mechanisms need to be worked out. Moreover, while technical progress is necessary and occurs under both protected and more open regimes, the type of technical change may be different in each case leading in differing consequences for the nature of growth of the economy. For example, it has been suggested that technical change may be more adaptive and less innovative under high protection, and more cost-reducing under the low protection of open economies. But no definite conclusions can be reached nor can any generalizations be drawn since one will have to come to terms with the phenomenon of import-substituting industries of today becoming the export industries of tomorrow in which case the connections between technical change for adaptation and subsequently for effective assimilation and innovation needs to be rigorously made. South Korea is a prime example of an economy that was/is both open and protected (Fransman, 1985).

It is our submission that statements of official policies need to be backed by sound empirical analyses of the phenomena being addressed, which of necessity implies an evaluation of the problems that the government thinks need rectification. This is because we believe that (if the economies of the East Asian countries present themselves as some sort of role models) governments do have the ability and the capacity to permanently alter the terms of international competition and irrevocably change the very structure of the market. In the Indian context, there are hardly sufficient studies of such an indepth nature to warrant the (beneficial) impact that the government options will (automatically) follow from its statement of Industrial policy, namely

- "The predictability and independence of action that this measure (namely the freedom to negotiate the terms of technology transfer with their foreign counterparts according to their own commercial judgement) is providing to Indian industry will **induce** them to develop **indigenous competence** for the **efficient absorption** of foreign technology; and
- Greater competitive pressure will [also] induce our industry to **invest much more in research and development** than they have been doing in the past" (Economic Times, 1991).

On the contrary, studies/data we have, while certainly critical of the ineffectiveness/even harmful nature of government intervention, point out at one level, to fundamental structural weaknesses afflicting the production system; at another level, they bring out starkly the inability of the political system to direct the economy towards certain well-defined economic goals.

Technical Performance of Indian Corporate Sector

In an earlier study we have examined in some detail the performance of the Indian corporate sector during the post-independent period which we have divided into three phases, namely,

- Period of liberalization until mid-sixties
- Period of tight regulation since then and until mid/late seventies, and
- Period of gradual relaxation from then onwards with the pace of relaxation accelerating from the mid-eighties onwards (Swaminathan, 1993).

Summarizing the conclusions from the above examination, we note the following:

During the early phase of industrialization (until the mid-sixties), when business houses/subsidiaries of multinational corporations had freely availed of imports and foreign technical collaboration/investment opportunities, their performance as documented by the Monopolies and Restrictive Trade Practices Commission, and as indicated in the nature of R & D undertaken by them, did not in any way contribute to make them innovative enough to be internationally competitive and/or dispense with further collaborations for the same product.

An examination of the performance of the capital goods sector during the period of regulation, namely, between 1973-74 and 1978-79, revealed two things: that the 'impressive' growth of the capital goods industry during the period under study could not have been possible in the absence of government policies; capital goods producers had acquired substantial innovative capacity only in 'standard' modern technology while being still very weak in 'highly' modern technology despite the increasing R & D expenditures (CMIE, 1984).

Jacobson's (1991) study of the engineering industry in the context of the new policy framework has brought out that while the liberalization measures have been successful in improving access to foreign technology, this has been at a price paid, in terms of both an inability to reap scale economies and a very poor innovate performance.

An examination of data provided by the Reserve Bank of India points to the dismal performance of the corporate sector in almost all indicators that one can associate with technological competence, namely, expenditure on R & D, volume of goods exported, value of imports and expenditure related to technology imports that is, royalty, technical and consultancy fees, dividends, etc.

This lends itself to two broad conclusions: Liberalization measures per se cannot impart that level of dynamism necessary to catapult a low level economy, technologically speaking, into an internationally competitive one; this transformation requires among other things, fundamental alterations in the production structure of the economy. There is a disjuncture in the authority structure of Indian society inasmuch as the state (which has brought into being and/or legitimated different forms of organizational enterprises in the economy) has not been able to get its economic programme implemented effectively through these enterprises. In other words, the role of the state, in general, and, more important, the need for the state to interact at a more intense level with business in particular, given the domestic and global environment facing the country are hard issues that need to be faced.

Liberalization measures per se cannot impart that level of dynamism necessary to catapult a low level economy, technologically speaking, into an internationally competitive one; this transformation requires among other things, fundamental alterations in the production structure of the economy.

In a thought provoking piece on the processes that lead to and/or hinder the accumulation of technological capability in developing countries, Bell and Pavitt (1992) have come out with a number of observations that are directly relevant for India. In the early stages of development, according to the authors, the accumulation of technology is influenced by factor endowments and intersectoral linkages. In later stages, the level of technological knowledge itself can become a source of comparative advantage reflected in production know-how, the design of capital goods, and a capacity for reverse engineering and imitative research and development, firms play a central role in this process. The authors reject any distinction being made between **innovation and diffusion** with its implicit assumption that technical change can easily and quickly be promoted through investment in new production capacity. Instead they distinguish such capacity from the resources and institutions that make up a country's technological capabilities, emphasizing the evidence that the accumulation of technology does not necessarily follow from policies to achieve other objectives; it must become a policy objective in its own right. The authors therefore very emphatically conclude that the failure to recognize the firm as the central player in the accumulation of technology has been a major shortcoming of technology policy in most developing countries.

Role of Firms: Organizational Structure

A related phenomenon that is increasingly being addressed in the literature on the dynamics of industrial capitalism is the dependence of a nation's competitiveness upon the organizational and financial capabilities of its firms and their supporting institutions. The works of Chandler (1990) and Lazonick (1990) are particularly constitutive of this kind of analysis. In Scale and Scope, Chandler examines the beginnings and subsequent growth of managerial capitalism in the United States. Germany and Great Britain, through an analysis of what he considers to be the basic institution, namely, the modern industrial enterprise. "Chandler's implicit thesis is that firms and markets evolve together to shape industrial outcomes. A perspective that relies on markets only as the lens through which to understand industrial development is likely to be seriously flawed. Rather the strategic and organizational choices made by managers – choices not necessarily dictated by markets and technologies – shape if not determine both firm level and national economic performance," (Teece, 1993, p 200),

Characterizing the US as the some of competitive managerial capitalism. Chandler points out that it was the modern hierarchical industrial firm that was responsible for America's growth. The firms that obtained market power rarely got it through artificial barriers or anticompetitive conduct. Neither did it come solely or even largely from the technical efforts of investors. Rather, it came from the ability to develop and commercialize the new technologies through the three-pronged strategy of investing in manufacturing, distribution and management systems and people. British economic development, in contrast, suffered during the second industrial revolution, because, British entrepreneurs frequently failed to make the essential three pronged investment in manufacturing, marketing and distribution, and management, "The pioneers recruited smaller managerial teams, and the founders and their families continued to dominate the management of the enterprise until well after World War II to the considerable detriment of the British economy. Boards of directors were restricted to family and those with family connections or social position, with little place for senior managers" (Chandler, 1990, p 235).

Developing further on the theme of organizational structures in the three industrial revolutions, Lazonick (1990) argues that in the British case, top management tends to be segmented not only from shop-floor operators but also form technical specialists, who, in both the United States and Japan are integrated into the managerial structure. The origins of British organizational segmentation lie in the combination of the legacy of craft control over work organization and the persistence of proprietory control of top management positions even in larger British firms. Moreover, notes Lazonick, the British practice of passing on control of the firm to family members, regardless of relevant, career credentials, has stifled the growth of the firm and the development of organizational capability. The proprietory firm often adopted a non-expansionary strategy in order to avoid becoming dependent on outside creditors or shareholders, or to avoid becoming subservient to a bureaucracy of technical specialists and middle managers.

The relevance of the above discussion to India can hardly be overemphasized. In the first place, the 'success' of the new policy measures depends primarily on the initiative and performance of the private sector. However, the organizational structure and capability of the different forms of production characterizing the Indian private sector is hardly a point of debate. Rather the policy statements overtly and covertly privilege the market over substantive firm level organizational changes to achieve competitiveness both at the national and international level.

Proprietary capitalism characterizes much of Indian private corporate sector.

Proprietary capitalism characterizes much of Indian private corporate sector; boards of directors, as in the case of Britain, are restricted to family and extended family members with little place for professionally qualified 'outside' personnel. Consequently, more often than not, the goal for family firms is not long term growth and profit but the provision of a steady flow of cash to owners. In such a milieu, accumulating wealth rather than making financial commitments to the rebuilding of organizational capability becomes the primary objectives.

In such a milieu, accumulating wealth rather than making financial commitments to the rebuilding of organizational capabilities becomes the primary objective.

The inability of the Indian State to operationalize its policies at the firm level is brought out very concretely in the studies done, for example, by the India-Japan Study Committee (1986). These studies are based on the experiences of the Japanese companies which were (as in 1985) in technology collaborative relations with Indian counterparts. We reproduce a part of the responses received by the Committee from Japanese companies (tables 1 & 2); the latter were asked to write down their most earnest request to their Indian partners, relating particularly to aspects of technology transfer.

'Opening up' of the economy to allow, among other things, easy importation of technology constitutes only the beginning; ultimately success depends mainly on the accumulation of experience and know how by improving upon imported technologies.

Thus on pain of repetition it needs to be underscored that 'opening up' of the economy to allow, among other

Table 1: Request by Japanese Companies to the Owners of their Indian Partners

I Technical awareness

1. Awareness on the importance of technologies and quality

(Ex.) "First priority should be given to the improvement of product quality."
"Similar quality, delivery period and prices to those in Japan should be ensured."
"Rapid localization is not appropriate."

2. Evaluation on intangible technology

(Ex.) "Intangible values (Industrial properties such as patent right and trademark right as well as know-how) must be fully understood and appreciated."

3. Accumulation of expertise and technical information

(Ex.) "Indian companies (although ambitious in their intentions) often try to enter new fields where they have no experience, in a total reliance on overseas technologies. This seems too easy." "Their expertise are extremely insufficient. Any party involved in technical collaboration should be prepared to visit the partner with relevant technical data for necessary consultations. Success of a project would depend on such enthusiams."

II Application and improvement of transferred technology

"It is not appropriate to rely completely on the licensor."
"It is necessary to develop international products (in terms of design, quality and prices) from a longer viewpoint. That will require constant improvement in the transferred technology. So far, there has been a repeated process that transferred technologies become obsolete in a few years and are replaced by new ones which are also transferred from abroad."
"They should make their own efforts to reduce local cost, instead of just requesting the Japanese partner to avoid cost increases."

III Management Method

1. Prevention of job-hopping

(Ex.) "Measures should be taken to prevent job-hopping of those engineers and workers who have acquired skills."

2. Development of human resources

(Ex.) "More middle-class engineers (site leaders) nurtured."

3. Decentralization of decision-making

(Ex.) "Bottom-up management is also important in addition to the top-down management."

4. Others

(Ex.) "Workers are poorly motivated. Necessary training should be provided to improve the situation."
"Class-consciousness should be lessened."
"Introduction of the Japanese style of management."

Source: Problems and Prospects of Technology Transfer between Japanese and Indian Companies, The India-Japan Study Committee, January 1986, p 37-39.

Table 2: Requests by Japanese Companies to the Engineers of Partner Firms

Directly related to mastering Japanese technologies		
1.	Awareness on the need of improved technological level.	
2.	Modesty in learing technologies	
	(Ex.)	"They tend to have too much pride, and should try to be modest in learning transferred technologies." "We want them to listen to our advice as far as Japanese technologies are concerned." "It is not appropriate to overestimate European technologies."
3.	Undesirability of continued reliance	
	(1)	Self-aid efforts
		(Ex.) "They should not rely totally on the licensor." "We want them to try to solve minor problems on their own as much as possible."
2.	Original modification and improvement not just copying	
		(Ex.) "Efforts should be made to modify Japanese technologies so that they would best suit in India." "Originality should be developed
4.	Others	
		(Ex.) "More study through literature is necessary in accumulating expertise." "We want them to be more informed of the product concerned.
	Work attitude of engineers	
1.	Improved awareness on product quality	
	(Ex.)	"It is sometimes considering in India that 'similar' things would do. Accuracy, quality, materials, etc. are not given first priority."
2.	Overcoming of sectionalism	
	(Ex.)	"Positive efforts are necessary to learn expertise and technologies even outside each person's field. They should not evade responsibilities nor make excuses."
3.	Practicality	
	(1)	Practical work attitude
		(Ex.) "They are argumentative, causing a delay in work. They do not take initiative in various activities. These tendencies should be changed." "In India, production techniques are often made light of due to too much emphasis on book knowledge. This has resulted in inadequate product quality." "They tend to stick excessively to what is written in documents. Instead, efforts must always be made to make modifications for improvement and develop new applications."
	(2)	Emphasis on site work
		(Ex.) "They tend to be 'desk' engineers. We want them to be practical engineers based on site experiences." "They should build up a habit of confirming site details by own eyes, not relying on knowledge or information provided. What is most important is 'management and work based on facts."
4.	Teaching of expertise to others	
	(Ex.)	"Know-how provided by the licensor should not be made personal properties." Provided expertise and technologies should not be in the possession of some individuals but should be utilized jointly with others."
5.	More effective training and management of workers	
	(Ex.)	"Operators should be trained and managed in a more effective manner."
6.	More effective preparation	
	(Ex.)	"Work must proceed according to a pre-determined schedule."

Source: Problems and Prospects of the Technology Transfer between Japanese and Indian Companies, The India-Japan Study Committee, January 1986, p 39-41.

things, easy importation of technology constitutes only the beginning; ultimate success depends mainly on the accumulation of experience and know how by improving upon imported technologies.

Conclusion

We began with the argument that the making of a competitive economy requires the simultaneous interaction of state and capital. More specifically, only a more developmental (less predatory) state will have the transformative capacity to command, monitor and get the private sector to perform. Organizational changes within the private sector are essential for firms to respond to, assimilate, and improve upon externally acquired technologies on a continuous basis. A developmental state can facilitate this process in a number of ways, the more obvious ones being through the financing of R & D, the explicit pursuit of relevant post graduate education (and subsequent work experience) etc. The important thing to realize, however, is that, mere government funded R & D and post graduate education, without matching technological capabilities and learning experience in firms is doomed to failure. The policy of setting up government-funded R & D particularly, is based on the fallacious assumption that the technology which emerges from R & D laboratories is easily transmissible and applicable.

We go along with Evans (1992) in stressing the need to focus more on state capacity as an important factor in policy choice and outcomes. Seen in this light, Evans argues that, the state's ability to perform administrative and other functions must be treated as scarce good. He separates India and Brazil from the East Asian developmental states to illustrate the point that the states in East Asia not only had higher levels of capacity but greater selectivity in the tasks they undertook. The developmental states focussed on industrial transformation and their strategies of promoting industry were designed to conserve administrative resources. As things stand, even if the Indian state were to accept today a more limited repertoire, we are not sure whether its existing capabilities can deliver the goods. Hence even with greater selectivity strengthening the capacity of the state is imperative for sustained structural adjustment. To conclude with Evans: "Pretending otherwise would be as dangerous as from the utopianism. Transforming the state from problem to solution must be central item on any realistic third world policy agenda" (1992, p 181).

References

Bell, Martin and Pavitt, Keith (1992) "Accumulating Technologies Capability in Developing Countries", Proceedings of the World Bank Annual Conference on Development Economies, IBRD/World Bank.

Centre for Monitoring Indian Economy (CMIE) Technology Issues in the Capital Goods Sector, UNCTAD/TT/55, (Reproduced), Bombay.

Chandler, Jr. Alfred D. (1990) Scale and Scope: The Dynamics of Industrial Enterprise, Cambridge, Mass: Harvard University Press.

Economic Times, (1991) "Text of Industrial Policy Statement", July 25.

Evans, Peter (1992) "The State as Problem and Solution: Predation, Embedded Autonomy, and Structural Change" in Haggard, Stephan and Kaufman, Robert, R., (eds.) The Politics of Economic Adjustment, Princeton University Press, New Jersey.

Fransman, Martin (1985), "Conceptualising Technical Changes in the Third World in the 1980s: An Interpretive Survey", The Journal of Development Studies, Vol. 21, No. 4, July.

Gerschenkron, Alexander (1962), Economic Backwardness in Historical Perspective, Cambridge, Mass: Belknap.

Granovetter, Mark (1985), "Economic Action and Social Structure: The problem of Embeddedness", American Journal of Sociology, Vol. 91 No. 3, November.

Hirschman, Albert (1958), The Strategy of Economic Development New Haven, Conn: Yale University Press.

The India-Japan Study Committee (1986), "Problems and Prospects of the Technology Transfer between Japanese and Indian Companies, January.

Jacobson, Staffan (1991), "Government Policy and Performance of the Indian Engineering Industry", Research Policy 20.

Lazonick, William (1990), "Organizational Integration in Three Industrial Revolutions", in Heerje, Arnold and Perlman, Mark (ed): Evolving Technology and Market Structure, Ann Arbor, The University of Michigan Press.

Nishimizu, M and S. Robinson (1983), "Trade Policies and Productivity Change in Semi-Industrialized Countries", Washington DC: World Bank, Development Research Department, Report No. 52.

Swaminathan, Padmini (1993), "Bridging the Technology-Gap: How Farsighted and Dynamic is the Indian Corporate Sector", Report prepared for the Development Research Group. Reserve Bank of India (forthcoming).

Teece, David, J (1993) "The Dynamics of Industrial Capitalism: Perspective on Alfred Chandler's Scale and Scope, Journal of Economic Literature, Vol. XXXI, March.

Unger, Kurt (1988), "Industrial Structure, technical change and microeconomic behaviour in LDCs", in Dosi, Giovanni, et. al, (ed.) Technical Change and Economic Theory, Pinter Publishers, London and New York. ☐

Focus

Export Competitiveness, Taxes & Domestic Welfare in India

M.R. Narayana

This paper reinterprets customs duties as a form of direct and indirect export duties, and argues for its spending to restoring the resource balance. These spendings are called direct subsidies for strengthening competitiveness of export trade in India. The customs duties net of these direct subsidies are treated as net export tax revenues on profitable export earnings, and the welfare effects of these tax revenues are examined. If domestic allocation of resources is welfare-maximising and the marginal utility of export tax revenue is positive, the welfare effect of export taxes is analytically shown to depending exclusively on export competitiveness. The empirical estimates show the positive welfare impact of net export tax revenues in India for most of the years during 1970-90, and especially increasing since 1986-90. This result, among others, supports the liberalisation measures on welfare grounds.

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Consider a world market structure which, in part, is characterised by larger number of sellers from different countries whose products are differentiable and substitutable in consumption.[1] In such a world market, a profitable price for marketed products differs between sellers due to their differences, among others, in production technology and transport cost, the cost of information technology (e.g., advertising and access to innovation in terms of R & D etc); resource cost of tariff and non-tariff trade barriers; and resource cost of various domestic fiscal policies (e.g. taxes and subsidies on foreign trade), monetary policies (e.g. interest rate policy) and stabilisation policies (e.g. exchange rate policy).[2] In general, seller-nations compete with each other in marketing their products at the highest profitable price, given the demand (or, market size) for the product. In fact, profitable prices will culminate in determining the profitable export earnings of each seller such that a stronger (weaker) competitiveness in terms of a lower (higher) selling price, other things being equal, will increase (decrease) the profitable export earnings. If the increased export earnings can be suitably taxed away (either in part or totally) and those tax revenues can be allocated to economic activities benefiting the entire national population, then there will be positive impact of export taxes on domestic welfare through competitiveness. This underlines the need for integrating the performance of export trade with domestic resource allocation in order to derive policy implications of export competitiveness for national welfare.

1 For an excellent discussion on the importance of market structure in international trade, see Helpman and Krugman (1990).

2 Cost of information technology and non-tariff barriers may also capture an element of non-price competitiveness in a world market. For a discussion on this point and for other related conceptual issues in international competitiveness, see Helleiner (1991).

If the increased export earnings can be suitably taxed away (either in part or totally) and those tax revenues can be allocated to economic activities benefitting the entire national population, then there will be a positive impact of export taxes on domestic welfare.

This paper reinterprets customs duties as a form of direct and indirect export duties, and argues for its spending to restoring the resource balance. These spendings are called direct subsidies for strengthening competitiveness of export trade in India. The customs duties net of these direct subsidies are treated as net export tax revenues on profitable export earnings or, in brief, net export tax revenues. In order to evaluate the resource allocative and welfare effects of these net export tax revenues, this paper develops a static model which captures the general equilibrium impact of competitive export trade on domestic welfare through optimal allocation of resources. This welfare approach is new to the extent it is not mentioned in the penetrating review articles on export competitiveness either in the past, for instance, by McGeehan (1962) or most recently by Sharma (1992).

Reinterpretation of data on Foreign Trade and Taxes in India

Table 1 provides several indicators of India's foreign trade performance during 1970-90 as well as the definitions of those indicators. First of all, India is an active open economy as measured by the degree of openness to external trade for last two decades. For instance, the openness has increased from 7.2 per cent in 1970 to 11.32 per cent in 1975, and from 14.05 per cent in 1980 to 16.05 per cent in 1990. Also, the degree of openness is consistently higher in 1980's as compared to 1970's, except for marginal fluctuations during 1982-87. This openness has been largely contributed by the better performance of

Table 1: Some indicators of foreign trade performance in India: 1970-1990

Year	Degree of Openness[1]	Exports as a % of GDP[4]	Exports as a % of total external debt	Imports as a % of GDP[4]	Imports as a % of total external debt	Resource balance[2] (Rs. in crores)	Average annual growth of exports (%)	Terms of trade[3]
1970	7.23	3.25	7.11	3.98	30.82	– 315.0	– 14.80	1.34
1971	7.67	3.36	6.80	4.31	30.73	– 439.0	1.50	1.31
1972	7.92	3.72	6.94	4.20	33.49	– 246.7	12.40	1.33
1973	8.19	3.79	8.21	4.40	39.97	– 373.9	0.80	1.26
1974	10.03	4.35	8.88	5.68	48.39	– 973.6	– 1.20	0.95
1975	11.32	5.30	9.37	6.02	57.47	– 562.3	6.10	0.96
1976	11.72	6.04	10.31	5.68	69.74	312.9	24.80	0.96
1977	11.41	5.65	10.48	5.76	69.18	– 111.3	2.10	0.97
1978	12.43	5.33	10.75	7.10	69.86	– 1839.0	– 3.60	0.96
1979	13.81	5.43	11.20	8.38	75.21	– 3377.4	0.30	0.91
1980	14.05	4.83	11.08	9.22	67.86	– 5964.8	– 9.10	0.84
1981	13.55	4.86	11.44	8.69	62.27	– 6121.5	– 4.30	0.89
1982	12.31	4.54	9.34	7.78	43.98	– 5776.1	13.90	0.91
1983	11.86	4.51	9.05	7.34	39.63	– 5868.5	7.30	0.97
1984	12.95	5.02	9.53	7.93	40.24	– 6723.8	1.80	1.00
1985	12.50	4.42	8.25	8.08	29.80	– 9588.8	– 3.90	0.96
1986	12.35	4.58	7.67	7.77	27.47	– 9295.8	6.20	1.00
1987	12.66	4.93	7.70	7.73	29.26	– 9296.9	14.60	1.00
1988	13.78	5.23	8.92	8.56	32.22	– 13143.5	9.10	1.00
1989	15.53	6.34	9.32	9.19	35.46	– 12601.6	14.40	1.07
1990	16.08	6.50	9.88	9.57	35.80	– 15668.6	8.60	0.96

Notes: 1. Degree of openness to trade = (exports + imports) / GDP) * 100.
2. Resource balance = Value of exports – value of imports, where all values of exports and imports are net of nonfactor services.
3. Terms of trade = Index of average export price, of f.o.b/index of averge import price, c.i.f. with the index 1987 = 100.
4. All GDP figures are used at market prices, i.e., GDP at factor cost plus indirect taxes less subsidies.
Source: Computed by the author based on World Bank (1992a; 320-323).

imports rather than exports as shown by the higher and increasing (especially since 1977) imports as a percentage of GDP, although export performance is consistently increasing during 1970-1976 as well as during 1985-90.[3] Surprisingly, the poor export performance is independent of the unstable growth of exports and the nature of terms of trade. This is evident in table 1 where the resource balance has remained negative whether or not the average annual growth of exports was high, and whether the terms of trade were favourable (i.e. greater than unity) or unfavourable (i.e. less than unity). Thus, the need for deliberate policy (e.g. taxes and subsidies intervention of improving export performance along with import restrictions needs no imphasis in India.

In India, the Federal government levies duties on foreign trade as a form of indirect taxes and provides export subsidies in the form of foreign trade and export promotional measures.[4] The foreign trade taxes are called customs duties and are in the form of pure export duties and pure import duties. The basic data on foreign trade taxes and subsidies are given in table 2.

Table 2: Foreign trade taxes and subsidies of the Federal Government in India (1970-90)

Year	Total tax revenue[3] as a % of GDP	Total indirect tax[4] revenue as a % of GDP	Customs duties as a % of GDP	Customs duties as a % of total tax revenue	Customs duties as a % total indirect tax revenue	Pure export taxes as a % of customs revenue	Export subsidies[1] as a % of customs duties	Ratio of export subsidy to pure export taxes	Net export tax[2] revenues (Rs. in crores)
1970	5.10	3.86	1.21	23.80	31.41	12.98	7.82	0.60	209.00
1971	5.30	4.19	1.50	28.38	35.88	10.84	7.79	0.72	256.74
1972	5.74	4.59	1.68	29.26	36.57	10.82	9.11	0.84	609.88
1973	5.55	4.34	1.61	28.94	37.02	8.81	7.79	0.88	622.48
1974	5.31	4.17	1.82	34.27	43.67	8.53	6.33	0.74	359.34
1975	6.47	5.02	1.80	27.84	35.87	10.56	11.35	1.07	856.75
1976	7.08	5.34	1.83	25.85	34.30	7.65	18.54	2.42	1553.70
1977	6.85	5.10	1.90	27.72	37.26	N.A.	19.02	N.A.	1712.72
1978	6.78	5.10	2.33	34.33	45.58	N.A.	17.32	N.A.	584.96
1979	7.49	5.88	2.56	34.13	43.47	N.A.	12.96	N.A.	- 453.44
1980	6.30	4.87	2.51	39.79	51.51	N.A.	12.52	3.53	-2555.84
1981	5.88	4.63	3.20	54.53	69.22	N.A.	9.95	N.A.	- 1002.51
1982	6.50	4.95	2.87	44.23	58.11	1.35	10.04	7.45	- 657.07
1983	6.29	4.84	2.69	42.76	55.54	1.43	10.03	7.00	- 285.45
1984	6.69	5.38	3.04	45.49	56.54	1.19	8.54	7.15	316.20
1985	6.76	5.40	3.64	53.84	67.41	0.87	6.33	7.27	- 62.82
1986	7.25	5.78	3.93	54.18	68.03	0.82	7.31	8.93	2179.23
1987	7.31	5.92	4.12	56.35	69.59	0.53	7.02	13.18	4405.10
1988	7.09	5.87	4.00	56.42	68.15	0.16	8.77	55.44	2661.50
1989	7.62	6.06	4.07	53.44	67.18	0.21	11.58	54.97	5434.38
1990	7.52	6.14	4.08	54.24	66.35	0.17	12.98	77.14	5131.45

Notes: NA: Not Available. 1. Export subsidies refer to the Federal budgetary expenditure (accounts/actuals) on foreign trade and export promotional measures.

2. Net export tax revenue = (Total customs duties – resource balance).

3. Total tax revenue includes taxes on income and expenditure; taxes on property and capital gains; and taxes on commodities and services from accounts data.

4. Indirect taxes refer to taxes on commodities and services. Other than customs duties, these taxes include federal excise duties, federal sales tax etc.

Source: Computed by the author based on the information in various issues of the Reserve Bank of India Bulletin in which the finances of the Government of India appeared.

3 In fact, a changing market share of India's exports in the world market can also be an indicator of export performance. But available data (in value terms) on the share of India's total exports in world market shows less than one per cent share over several decades, although exports have grown in absolute size (uncorrected of inflation) during the same decades. Thus, for evaluating the export competitiveness at the aggregate level, market share approach may not be interesting for India.

4 In addition to federal subsidies, the state governments in India may also provide supplementary subsidies in the form of fiscal and financial incentives for export enterprises located within their jurisdictions. Such locational incentives are in practice in states like Gujarat, Maharashtra etc.

Government levies duties on foreign trade as a form of indirect taxes and provides export subsidies in the form of foreign trade and export promotional measures.

The table shows that, over the years, the total tax revenue, indirect tax revenue, and revenue from customs duties have been increasing as a percentage of GDP. The increase in total tax revenue is mainly accountable for indirect tax revenues, and the increase in indirect tax revenue is mainly accountable for customs duties. More particularly, the increase in customs duties are mainly due to increasing pure import duties since pure export duties as a percentage of customs duties are quite negligible, especially during 1980's. This fact need not undermine the role of export duties altogether, since several imports are for exports and such import duties are a form of export duties as well. From this viewpoint, one may approximate pure import duties as a form of indirect export duties, and reinterpret customs duties as the sum of direct and indirect export duties. This reinterpretation of customs duties/taxes will be referred to as total export duties in the following analysis.

On the other hand, the Federal government in India offers various fiscal and non-fiscal incentives for export (import) promotion (reduction). In general, these incentives include: imports for exports policies (e.g. duty-free imports of inputs and capital goods, establishment/improvement of duty drawback schemes, retention of foreign exchange receipts etc); quantity restrictions and reduction in export tax policies (e.g. removing/liberalising export restrictions, controls, and regulations in the form of export licenses, quotas, taxes etc); export credit and financing policies (e.g. initiating/strengthening of export credit schemes of pre- and post-shipment financing, domestic letters of credit, priority access to credit and tax rebates credit etc); and export promotion and organisational policies (e.g. institutional changes to promoting export diversification, marketing and production etc.).[5] These measures have been evolved over the years and are well documented in various (NCAER, 1969; Panchamukhi et al., 1991; and Narayana, 1992).

5 The trade policies above are also the same as the conditionalities on trade reforms for the World Bank loans under Structural Adjustment Programmes (i.e. the package of measures designed to direct and economy away from central planning and control towards a well-functioning free-market system based on competition, liberalisation, deregulation, and an enhanced private sector). See, for instance, World Bank [1992b].

The performance of Federal government's budgetary spending on foreign trade and export promotion during 1970-90 is also given in table 2. These spendings as a percentage of total customs duties have been stepped up especially since 1975 and have remained higher as compared to pure export taxes as a percentage of total customs duties. These expenditures are considered a form of indirect fiscal incentives for export promotion.

Notwithstanding these fiscal incentives, the resource balance has continued to fluctuate over the years. Further, the export incentives have failed to be self-financing by the export sector. This is evident from the ratio of export subsidy to pure export taxes being more than unity for all the available years since 1975. In this situation, one may consider a policy alternative of spending a part of the total export duties to giving direct subsidies in order to restore resource balance whenever it is negative. In this way, the external sector can be self-financing of its own deficit. The amount of total export duties after meeting this direct subsidy requirements may be called net export tax revenues on profitable export earnings to the Federal government in India. In fact, the net export tax revenues have been positive for most of the years during 1970-90, and especially increasing over the years in the 1980s as shown in table 2.

The positive net export tax revenue is an additional source of income available for domestic economic activities (production, consumption etc.). This source of income is most important for India since the domestic absorption of GDP has been greater than cent per cent for almost all the years during 1970-90. This fact is revealed in table 3 where the domestic absorption of GDP is computed with respect to private consumption, general government consumption, and gross domestic investment.

In simple macroeconomic terms, the excess of domestic absorption over GDP must be contributed by the negative resource balance. For instance,

$$\text{Let GDP} = C + I + (X - M),$$

where C is the sum of private and government consumption,

I is the domestic investment,

X is the total exports, and

M is the total imports,

Then, $(C + I) > \text{GDP}$ clearly implies that $(X - M) < 0$.

In the reinterpretation of the basic data, the direct subsidy influence on domestic absorption of GDP and the positive net export tax revenue constitutes the available resources for further domestic absorption.[6] Thus, net export tax revenues are ultimately welfare-changing. This provides a basis for examining whether or not the welfare (e.g. changing domestic absorption of GDP) of the people in India is better off because of net export tax revenues.

Table 3: Domestic absorption of GDP in India (1970-90)

Year	Private consumption as a % of GDP	General government's consumption as a % of GDP	Gross domestic investment as a % of GDP	Sum of (2), (3) and (4).
(1)	(2)	(3)	(4)	(5)
1970	74.75	8.90	17.10	100.74
1971	72.78	9.64	18.48	100.91
1972	74.04	9.27	17.10	100.41
1973	73.94	8.32	18.27	100.53
1974	72.81	8.52	19.77	101.11
1975	70.18	9.37	20.84	100.38
1976	68.62	9.69	20.94	99.26
1977	70.58	9.12	19.80	99.50
1978	69.58	9.33	22.29	101.20
1979	69.58	9.77	22.86	102.20
1980	73.01	9.62	20.92	103.54
1981	68.65	9.61	25.04	103.30
1982	69.54	10.26	22.89	102.69
1983	71.37	10.18	20.74	102.29
1984	70.74	10.52	21.09	102.35
1985	67.92	11.14	24.03	103.09
1986	67.86	11.86	23.03	102.75
1987	67.59	12.34	22.67	102.59
1988	67.22	11.95	23.89	103.06
1989	67.02	11.99	23.58	102.58
1990	67.51	12.10	23.17	102.78

Source: Computed by the author based on the information in World Bank (1992a)

Theoretical Analysis

The theoretical analysis is intended to obtain simple testable hypotheses for welfare effects of export taxes due to competitiveness. In order to simplify the analysis and to attaining generality of results, the following assumptions are made:

A world with a fixed number of independent nations (sellers) is considered where nation i denotes the home country and j denotes the rest of the world. The total population (or, labour force) in i is L_i and in j is L_j. Total population in the world is L $(= L_i + L_j)$ and is fixed. Each labourer possesses a given unit of labour which is immobile between nations.

The domestic economy is assumed to produce a homogenous output, Y, under conditions of neoclassical technology with labour and fixed land/natural resource $(\overline{Z})$ as domestic inputs and with fixed amount of non-competitive imports from the rest of the world as non-domestic input. That is, $Y = F(L_i, \overline{Z}_i, \overline{M}_i)$, where F is the well-behaved production function. Secondly, it is assumed that the domestic factor market is competitive. Let output price be fixed and set to unity. Then, given domestic wage rate (W_i), national output (Y_i) is assumed to be determined under profit maximising conditions by the choice of (L_i). Thus, labourers are paid wages according to their marginal product, $[dF_i/dL_i] = [F_i']$ and the residual output is defined by: $(F_i - L_i \,.\, F_i') = R_i$. Third, it is assumed that public ownership of land/natural resource and resource rents are captured by the national government and that the residual output is used, in part, to financing imports and the balance is equally shared by every labourer within the nation as per capita resource rent which equals to: $r_i = [(R_i - \overline{M}_i)/ L_i]$.

Further, the domestic economy is assumed to have a government whose functions are two folds.[7] First, redistribute resource rents on equal per capita basis within the nation as described above. Second, determine the allocation of total output between uses such that the welfare of its population is maximised. Assuming that all labourers in the nation are rational, identically treated, and have identical preferences as given by the standard quasi-concave utility function of a representative labourer, U [. , .], the resource allocation problem can be formulated as follows. Throughout, the utility function is treated as a proxy for welfare function of a representative labourer.

Impact of Export Taxes on Domestic Resource Allocation

A two-stage allocation problem is considered. In the first stage, the government shall determine the allocation of total output between domestic use and exports. That is,

$$\max_{\{X_i,\, E_i\}} W = u\,[X_i,\, E_i]; \tag{1}$$

$$s.t.\!: \; Y_i = X_i + X_i^* = P_i \cdot X_i + P_i^* \cdot E_i \tag{2}$$

6 In the presence of unemployed factors of production (e.g. labour), the increased domestic absorption may in turn lead to positive effects of short-term Keynesian type multipliers on output/employment. In this way, export competitiveness will influence domestic welfare through economic growth as well.

7 The model neglects redistribution function of the government by implicitly assuming optimal income distribution within the national economy.

where X_i is the domestic use of Y_i

E_i is the export of Y_i

P_i is the domestic price of X_i

$P_i^* = \{ P_i^{**} - (P_i + K_i)\}$ is the export price for i in the world market where K_i is the cost of transportation and other expenses to be incurred in shipping the goods to world market

P_i^{**} is the world market price which does not equal to P_i^*. Throughout, it is assumed that the national economy is a small economy, i.e. it takes P_i^{**} as given.[8] Note that if P_i^* is constrained to be non negative, it will also ensure that exports are competitive or profitable.

The first order conditions for the maximisation problem in (1) and (2) yield:

$$U_x/U_{Ei} = P_x / P_i^* \quad (3)$$

where $U_{xi} \equiv (\delta U / \delta X_i) > 0$ and $U_{Ei} \equiv (\delta U / \delta X_i) > 0$ are the positive marginal utilities of X_i and E_i.

Equation (3) has the standard interpretation of marginal equilibrium condition for a pure private good in the neoclassical theory of consumer behaviour, viz, the marginal rate of substitution between X_i and E_i be equal to their respective price ratios. The optimal solutions for $\{X_i, E_i\}$ will be denoted by $\hat{X}_i$ and $\hat{E}_i$ so that $\hat{X}_i^* = (P_i^* \cdot \hat{E}_i)$.

In stage two, the government will determine the allocation of optimal total domestic resources $(\hat{X}_i)$ between private consumption (C_i) and public use (G_i). It is implicitly, considered that G_i is a pure public good whose benefits are restricted to residents within the nation. Let the cost of public goods supply (G_i) be financed by domestic as well as by export taxes. Domestic taxes are considered to be uniformly shared in the form of residence-based taxes. Let the domestic tax rate be t. Then, the total domestic tax collection $T = (t \cdot \hat{X}_i)$. In the same way, let the tax rate on profitable export earnings be: t^*. Then, the total export tax collection equals to: $T^* = (t^* \cdot \hat{X}_i^*)$. Hence, $G_i = (T_i + T_i^*)$ and per capita private consumption is: $c_i = [(\hat{X}_i / L_i) - (T_i / L_i)]$. In this post-export stage, the government's allocation problem can be formulated as follows.

$$\max_{\{c_i, G_i\}} W^* = U[c_i, G_i]; \quad (4)$$

$$s \cdot t{:}\ (1)\ c_i = [(\hat{X}_i / L_i) - (T_i / L_i)] \quad (5)$$

$$(2)\ G_i = (T_i + T_i^*) \quad (6)$$

The formulation in (6) is intended to capture the benefits of export tax revenue for the economy as a whole and to link the export sector with the domestic economy. In this formulation, profitable exports may improve (or worsen) domestic welfare through reduction in domestic tax burden (or private consumption). Alternatively, export taxes may be interpreted as a way of partly financing the public sector investments which are conducive to exporting industries.

Export taxes may be interpreted as a way of partly financing the public sector investments which are conducive to exporting industries.

From the necessary conditions for the maximisation in (4)-(6), following result is obtained.

$$[L_i \cdot (U_{Gi}) / (U_{ci})] = 1 \quad (7)$$

where the marginal utilities of c_i and G_i are assumed to be positive. This is the familiar Samuelsonian conditions in the welfare-economic theory of public goods. This condition states that, for the supply of pure public goods to be Pareto-optimal, the sum of marginal rate of substitutions must equal to the marginal rate of transformation. Thus, equation (7) is the basic condition for the optimal allocation of domestic resources in the present model.

Impact of Export Taxes on Domestic Welfare

Consider a situation where the Government may want to increase the tax revenue from the export earnings.[9]

8 In a way, the world market price, P_i^{**}, captures the nature of production, consumption, public sector, and resource base in the rest of the world economy. Since P_i^{**} is exogenously given, the factors affecting it are not a part of any endogenous determination of the domestic economy. It is for this reason, the model has not characterised the rest of the world economy.

9 An increase in profitable export earnings is possible without being domestically productive (or, without directly or indirectly contributing to domestic output through production). In this case, a tax on such earnings is called domestically unproductive profit-seeking (DUP) activity, or a form of rent-seeking activity. In our analysis, the export taxes (either total or net) do not conform to this DUP activity because these taxes are mostly on imports which may be contributing to exports through domestic production (e.g. fertiliser imports for agricultural exports). However, this model cannot separate the import-intensity of exports since exportable output is part of single homogeneous output produced. For an excellent analytical discussion on unproductive profit-seeking activities, see Chapter 30 in Bhagwati and Srinivasan (1983).

For this purpose, it will have to change the tax rate on export earnings. The consequence of this change in export tax rate (t^*) on domestic welfare can be determined as follows.

Assume that the government has a Benthamite social welfare function (W^{**}) which represents the aggregate domestic welfare function of total domestic private consumption, public consumption, and tax revenue from exports as defined below.

$$W^{**} = L_i \cdot U[c_i, G_i, T_i^* / L_i] . \quad (8)$$

Totally differentiating (8) with respect to t^*, we get

$$dW^{**}/dt^* = L_i \cdot U_{ci} \cdot (\delta c_i / \delta G_i) \cdot (\delta G_i / \delta t^*) + (L_i \cdot U_{Gi} \cdot (\delta G_i / \delta t^*) + U_{Ti}^{**} (\delta T_i^* / \delta_t^*), \quad (9)$$

where U_{Ti}^* (marginal utility of T_i^*) is assumed positive. In fact, equation (9) is an expression for a marginal social welfare change in the economy due to changes in t^*. The first term on the right hand side of (9) is the private consumption effect and the second term is the public consumption effect of changes in t^*. These two consumption effects may account for the resource allocative effects. The last term on the right hand side of (9) is the effect of changes in export taxes on export tax revenue of the government. This effect may be called revenue effect. Thus, when the export sector is integrated with the domestic sector, changes in export tax will affect domestic welfare through resource allocative effects and revenue effect.

Since $[\delta c_i / \delta G_i] = -(1/L_i)$, and $[\delta G_i / \delta t^*] = [\delta T_i^* \; \delta t^*] = (\hat{X}_i^*)$, equation (9) can be rewritten as follows:

$$dW^{**} / dt^* = [L_i \cdot \{U_{Gi} - U_{ci} / L_i\} + U_{Ti}^*] \cdot (\hat{X}_i^*), \quad (10)$$

Substituting (7) in (10), we get

$$dW^{**} / dt^* = U_{Ti}^* (\hat{X}_i^*) . \quad (11)$$

That is, if the domestic resources are optimally allocated between private and public consumption uses as given by the Samuelsonian condition (7) and if the marginal utility of T_i^* is positive, then the changes in national welfare due to changes in export taxes depend only on the nature of profitable earnings or export competitiveness.

What will be the nature of welfare effects if the domestic resource allocation is non-optimal in (10)? Interestingly, the conditions of welfare change in (11) will remain valid even in the presence of non-optimal domestic allocation, provided the nature of non-optimal domestic resource allocation is given by the inequality: $(U_{Gi}) > (U_{ci}/L_i)$. However, if $(U_{Gi}) < (U_{ci}/L_i)$, then the relationship between welfare changes and export taxes will be ambiguous within the available information in our model.

Equation (11) is used as the basis for empirical estimation of welfare consequences of changes in export taxes in India.

Empirical Analysis

In order to empirically determine U_{Ti}^* in (11) the following mode is formulated which expresses domestic welfare (D) as a function of total export taxes (T^*),

$$D = g(T^*) \quad (12)$$

It is assumed that the functional relationship between D and T^* is of Cobb-Douglas type. In double logarithmic form, this relationship can be expressed stochastically with additive random disturbance (term (ε) as follows:

$$\log D = \alpha + \beta \log T^* + \varepsilon . \quad (13)$$

where ε is assumed to satisfy the standard assumptions of a linear regression model. Hence, (13) can be estimated by the technique of Ordinary Least Squares (OLS).

Equation (13) is estimated using the time series data of 1970-90 on actual domestic absorption of GDP (as an approximate indicator of domestic welfare) at market prices and total customs duties as a proxy variable for T^*. The sign of β is predicted to be positive since, other things being equal, an increase in total export tax revenue is expected to be welfare improving.

It is often argued (e.g. Debroy, 1992, 37) that the policy of economic liberalisation in India (in terms of reduction in the incidence of controls and regulations) got a strong impetus since 1985, although it had actually started during late 1970's and continued through 1980-85. Since the period of the empirical study actually covers these liberalisation periods, the results may be said to provide an indirect welfare evaluation of liberalisation policy as well.[10]

The OLS estimates of the parameters in (13) are as follows:

$$\log D = \underset{(100.58)}{4.85} + \underset{(52.34)}{0.68} \log T^* \quad (14)$$

Number of observations = 21; Adjusted R^2 = .990
Standard error of forecast = 0.066; Durbin – Watson Stat = 1.49

where the figures in the parentheses are t-ratios which are highly significant. The adjusted R^2 shows the high ex-

10 For a brief review of liberalisation in 1980's see EIS (1990).

planatory power of the model with regard to variable T^*. The upper critical value (d_u) of the Durbin-Watson test at 5 per cent significance level with 21 observations and with one explanatory variable is 1.42. Thus, the Durbin-Watson statistic 1.49 is greater than d_u but less than 2. Following Pindyck and Rubinfeld (1981) this result tests for the absence of serial correlation in our estimation.[11]

As predicted, the estimated β is positive and statistically highly significant. This result may be interpreted that the marginal domestic welfare is positively related with the total export taxes in India.[12] Consequently, the nature and magnitude of welfare effect of total export taxes are solely determined by the nature and magnitude of export competitiveness.

Marginal domestic welfare is positively related with the total export taxes in India.

Profitable export earnings are considered to be totally taxed away as export taxes. Hence, net export tax revenue in table 3 is equivalent to profitable export earnings. Using this data and estimated coefficient of T^* in (14), the marginal social welfare gains are computed based on equation (11). The results are presented in table 4 which also gives estimates of per capita marginal social welfare gains for 1970-90.

Table 4: Marginal Welfare Gains from Net Export Tax Revenue: Estimates for India (1970-90)

Year	Marginal social welfare gains (in billions of rupees)	Per capita marginal social welfare gains (in rupees)
1970	1.42	2.59
1971	1.75	3.12
1972	4.15	7.24
1973	4.23	7.22
1974	2.44	4.07
1975	5.83	9.50
1976	10.57	16.82
1977	11.65	18.14
1978	3.98	6.05
1979	– 3.08	– 4.59
1980	– 17.38	– 25.30
1981	– 6.82	– 9.70
1982	– 4.47	– 6.22
1983	– 1.94	– 2.64
1984	2.15	2.87
1985	– 0.43	– 0.56
1986	14.82	18.95
1987	29.95	37.49
1988	18.10	22.18
1989	36.95	44.36
1990	34.89	41.05
Average annual growth rate	7.44	9.63

Note: In arriving at per capita figures, the marginal social welfare gains were divided by the estimated total population size of respective years as given in World Bank (1992a; 320-323).
Source: Computed by the author.

The results show that net export taxes have contributed to increasing domestic welfare in India both over a period of time in general and for different periods in particular. For instance, in aggregate (per capita) terms, the increase is from Rs. 1.42 billion (Rs. 2.59) in 1970 to Rs. 11.65 billion (Rs. 18.14) in 1977, and from Rs. 14.82 billion (Rs. 18.95) in 1986 to Rs. 34.89 billion (Rs. 41.05) in the 1990. Moreover, on an average, for the period 1970-90, the marginal social welfare (per capita) gains have been positive at Rs. 7.44 billion (Rs. 9.63) per year.

Conclusion & policy implications

If domestic allocation of resource is welfare maximising and the marginal utility of export tax revenue is positive, this paper has analytically shown that welfare effect of export taxes depends exclusively on export competitiveness. The empirical estimates show the positive wel-

11 For reconfirming the absence of serial correction in the estimation, the model was reestimated in (13) by Cochrane-Orcutt technique, or by employing the First-Order Autoregressive Correction [AR (1)]. The estimation results where the convergence was achieved after two iterations are as follows.

$$\log D = 4.79 + 0.69 \log T^* + 0.15 \,.\, AR(1)$$
$$(76.54) \quad (42.13) \quad (0.64)$$

Number of observations = 20 (1971 – 90); Standard error of forecast = 0.063; Durbin-Watson stat = 1.7.

The coefficient of the term AR(1) is called serial correlation coefficient of the unconditional residuals. This coefficient is related to computed Durbin-Watson statistic above by being equivalent to: [2 – (0. 15*2)]. Since this Durbin-Watson statistic is greater than d_u but less than 2, the absence of serial correlation is once again demonstrated.

12 These estimates are valid even if $U_{T_i^*}$ is estimated for different periods within the sample. For instance the sample was divided between 1970-79 and 1980-90, and re-estimated in (13). The estimated coefficients and other statistics were qualitatively similar to the estimated coefficients in equation (14). Hence, the separation of sample between two time periods does not alter the nature of any conclusions. These econometric results are available upon request.

fare impact of net export tax revenues in India for most of the years during 1970-90, and especially increasing for all the years during 1970-77 and 1986-90. Since the economic liberalisation has been strongly implemented in India since the middle of 1985 as a strategy for boosting exports, the positive and increasing social marginal welfare gains of every year during 1986-90 offer indirect testimony for the success of liberalisation measures on welfare grounds. Thus, the results of this paper offer both analytical and empirical justifications for export taxes as a policy instrument for national welfare in India. Accordingly, the results reject the general belief that export taxes as such may have deterrent effect on export performance and, ultimately, on domestic welfare; and the conventional wisdom that exporting too little and importing too much as a general misconception.

The Tax Reforms Committee (Chairman: Raja J. Chellaiah) in 1992 has recommended a programme of import tariff reduction, and argued that there will be no shortfall in customs even with a 50 per cent reduction in average tariff rate, if imports grow very fast (say, due to liberalisation policies or increased exports). This recommendation seems to have a favourable implication only in the long run, since in the short run a cut in import duties will entail a revenue loss to the government. This is evident from several changes in import duties which have been announced for 1993-94 as to be effective from February 28, 1993.[13] These changes are estimated to result in a revenue gain (due to increase in duties) of Rs. 78 crores as against a revenue loss (due to reduction in duties) of Rs. 3351 crores. Thus, net loss of import duties is about Rs. 3273 crores. The results of this study indicate that this short term revenue loss may have unambiguous welfare loss for the people, if it results in a negative net export tax revenues. Consequently, budgetary proposals with regard to foreign trade taxes need to be carefully re-examined in the light of their ultimate welfare implications.

A major limitation of the study is the absence of external debt and the neglect of income distribution. Their inclusion will help in realistic assessment of welfare gains from external trade (especially under Structural Adjustment Programmes in 1990's) and in establishing the generality of results obtained in this paper. Secondly, India is a federation of competitive regions and interregional implications of national welfare due to export taxes is of utmost policy importance for balanced regional development. This is an instance for national policy instrument which can be aimed at spatial equity in the process of economic development. These works are the fruitful areas of future policy research in India.

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References

Bhagwati, J.N. & T.N. Srinivasan, (1983). Lectures on International Trade, The MIT Press (Mass).

Debroy, Bibek, (1992) Foreign Trade Policy Changes and Devaluation: Current Perspectives, B.R. Publishing Corporation (New Delhi).

EIS [Economic Intelligence Service]. (February, 1990). The Liberalisation Process, Centre for Monitoring Indian Economy (Bombay).

Helleiner, Gerald K. (1991). "Increasing International Competitiveness: A Conceptual Framework", in Yin-Kann Wen and Jayashree Sengupta. (eds). Increasing the International Competitiveness in Exports from Caribbean Countries, EDI Seminar Series, The World Bank (Washington), 17-26.

Helpman, Elhanan & Paul R. Krugman. (1990). Market Structure and Foreign Trade, The MIT Press (Mass).

Hoffmaister, Alexander. (1992). "The cost of export subsidies", IMF Staff Papers, Vol. 39, 148-174.

McGeehan, J.M. (1962). "Competitiveness: A survey of recent literature", The Economic Journal, Vol. 78.

Narayana, M.R. (1992) "Export subsidies in India: Need for a strategic approach", Foreign Trade Review, Vol. XXVII, 35-50.

NCAER, [National Council of Applied Economic Research]. (1969). Export Strategy for India, NCAER (New Delhi).

Panchammukhi, V.R. *et al.*, (1991). Export Financing in India, Interest Publication (New Delhi).

Pindyck, Robert S. & Danial L. Rubinfeld. (1981). Econometric Models and Economic Forecasts, McGraw Hill (New York).

RBI [Reserve Bank of India]. (1993). "Finances of the Government of India, 1993-94: Appendix-II, Reserve Bank of India Bulletin, Vol. XLVIII, 638-641.

Sharma, O.P. (1992). "Export competitiveness: Some conceptual issues", Foreign Trade Review, Vol. XXVII.

World Bank (1992a). World Tables: 1992. The John Hopkins University Press (Baltimore).

World Bank (1992b). Trade Policy Reforms under Adjustment Programs, The World Bank (Washington D.C.). □

13 See, RBI (1993) for details of these changes in import duties for 1993-94.

Towards A New Management Paradigm

Greg Bounds & Aaron Fausz

Recent changes in the business environment have fundamentally altered the way organizations operate. As a result, prevailing paradigms of management based on the classical school of management have become inadequate for understanding or applying management to today's rapidly changing business environment. A revolutionary view of management is required for organizations to survive. Furthermore, a fundamental change in the culture of organizations is required to support the shift to a new, more realistic management paradigm, elucidate the authors.

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A number of revolutionary changes are sweeping through the business world. These changes are rewriting the rules of the economic game and altering the environment in which organizations operate. Contemporary organizations must contend with the rapid and pervasive introduction of new technologies, the availability of voluminous amounts of realtime information, international standards of performance (e.g., ISO 9000), domestic economic upheaval, and a workforce defined by near illiteracy at one end of the spectrum and a high degree of education, mobility, and aspirations at the other end. In addition, factors such as fluctuating exchange rates and improved transportation and logistical systems have increased the flow of goods and services across borders, opening up new markets for many companies. As a result, customers have increased their demands for a wider variety of higher quality products and services, which in turn has intensified international competition.

The cumulative impact of all these factors has accelerated the pace of change and exacerbated the impact of the new competitive forces. Increased competition has made things more unstable, and there is no sign of abatement. Given such dramatic changes, an equally revolutionary view of management is required for organizations to survive. The prevailing paradigms of management are largely outdated; fundamental changes in the culture of organizations are required to support the shift to a new, more realistic management paradigm.

What Is A Paradigm?

Kuhn (1962) believed that progress in science was not made by a steady stream of advancement, but resulted from discontinuous jumps in understanding that occurred when an existing body of knowledge no longer explained the phenomena being observed. For example, early astronomers believed that all celestial bodies revolved around the earth, which was believed to be the center of the universe. With time and the development of better equipment, astronomers began to observe planetary movements that could not be explained by this system of thought. Thus, a radically different set of beliefs and assumptions had to be developed to explain the new discoveries. Kuhn used the word paradigm to represent the "universally recognized scientific achievements that for a time provide model ideas, measurements, and solutions to a community of practioners."

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Although initially applied to the development of science, the concept of paradigm also applies to organizations and management. In this sense, a paradigm provides rules and standards for managerial theory and behaviour, as well as accepted examples of managerial practice, application, and instrumentation. For simplicity, we define a managerial paradigm as *the way managers think and act in conducting business.* Paradigms are essential for human existence because they provide ways of looking at the changing world. They serve as conceptual roadmaps for organizational members to explain how the organization functions. Paradigms also serve as the base from which organizational leaders set goals and make decisions. However people are often unaware of their existence or how they affect our lives. Paradigms are analogous to wearing a pair of prescription glasses or contact lenses. Individuals often forget they are wearing them, but they provide the focus through which we see the world.

When evidence begins to disconfirm the reigning paradigm, there is usually considerable resistance to a change in or abandonment of it. But it is this evolutionary emergence of new paradigms that enhances our ability to more clearly understand and to more lucidly explain the complex phenomena we observe and experience. In order to understand why and how current management paradigms must be changed, we will trace the evolution of existing management thinking, paying particular attention to the quality revolution.

The Development of Management Paradigms

Historically, our understanding of the role of management in organizations has been strongly influenced by the models that gave rise to the classical school of management. The work of Charles Babbage, Henri Fayol, Max Weber, Frederick Taylor, and Frank Gilbreth fathered a rational view of organizations which perceives management as grounded in a quantitatively oriented set of activities that occur in a highly structured, hierarchical organization ruled by calculation and control. This classical approach revolves on managers planning, organizing, direction, and controlling the organization's human and material resources. As such, managers are seen as administrators whose focus is on the control of others and whose main purpose is to manage the organization toward short-term goals with a predominantly fiscal orientation.

The influence of the rational view can be seen today in many organizations. Hierarchical structures, rigid divisions of labor, specialization of tasks, appointment by merit, promotion on the basis of ability and experience, planned career opportunities, rules and regulations to guide behaviour, and specification of authority and responsibility all follow the traditions of scientific management and fit into the rational view. Such a rational approach led to a number of problems at Xerox that lowered the quality and competitiveness of its products in the mid 1970's and early 80's. Rigid divisions of labor and specialization of tasks created an atmosphere of functional optimization, which left Xerox with a fragmented and inefficient use of resources. Xerox managers around the world were holding inventory and doing their own hedging and balancing. As a result, Xerox had a lot of inventory collecting dust. For example, a manager in the United States may have needed parts from an old copier in a French warehouse. But the information systems to reveal its availability did not exist, nor did the French managers have any incentive to share it. Because of this, millions of dollars in unused assets were still on the balance sheet, customers were not served optimally, and Xerox's global market shared declined. But in 1984, David Kerns (then CEO of Xerox) launched an ambitious quality improvement program to reverse these trends by changing the perceptions of managers away from functional optimization to global optimization. This effort was successful in turning Xerox's fortunes around, but the push for providing better customer service continues at Xerox.

Many other organizations are also beginning to realize that such a rational, impersonal view of management is outdated and inappropriate in light of the dramatic changes taking place in the business environment. However, although management literature has challenged the fundamental tenants of scientific management, incumbent paradigms and practices die hard. Many new approaches have been attempted with varying degrees of success. An approach that has had a profound impact on organizations is the focus on quality. Over the years managerial approaches to quality have evolved from a narrow view-focused on inspection and conformance to specified standards toward a broader view focused on organizational strategies for providing superior customer value. Garvin (1988) identified distinct eras through which equality has evolved. We will briefly review here these eras.

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The inspection era. Until the nineteenth century, skilled craftsmen manufactured goods in small quantities. They hand-crafted parts to form unique products that were only informally inspected. The industrial revolution brought increased specialization, division of labor, and mass production to the workplace, which required more formal inspection. People used gauges to examine the suitability of products, making inspections more consistent and reliable. This practice became more and more refined through the 1920's. it was prominent in Henry Ford's moving assembly line and Frederick Taylor's system of shop floor management. However, because quality control was limited to inspection, it most often focused on activities such as counting, grading, and rework. Inspectors were not required to troubleshoot or to understand and address the causes of poor quality until the creation of statistical quality control. ·

The statistical quality control era. Shewhart (1931) gave quality a scientific footing when he argued that quality could be systematically monitored and improved. This approach was grounded on the notion that variation was a part of industrial life. The issue of quality became one of acknowledging variation and using principles of probability and statistics to distinguish acceptable (normal) variation from unacceptable (abnormal) variation. Plotting data graphically with statistical limits enabled managers to assess whether the numbers fell within the acceptable range and to identify potential causes of abnormal variation. Shewhart's approach also suggested drawing samples of output throughout the production process, rather than waiting until after final assembly. Many U.S. manufacturers used Shewhart's techniques during World War II to provide the Army with the large quantities of high quality arms and ammunitions it required for the war effort. However, after the war, quality control in American industry remained largely inspection-based. The Japanese, in contrast, continued to develop and apply methods for continuous improvement in an attempt to rebuild their devastated country.

The quality assurance era. During the 1950's and early 60's the concept of quality in the United States evolved from a narrow, manufacturing-based discipline to one with implications for management throughout an organization. Statistics and manufacturing control remained, but coordination with other areas such as design, engineering, and planning also became important. In addition, a more proactive approach was taken with regard to defect prevention. This era is best represented by Feigenbaum (1956), who suggested that high-quality products are more likely to be produced through "total quality control" than when manufacturing works in isolation. This era significantly expanded the involvement of all other functions in total quality control and inspired managers to actively pursue perfection. However, the approaches to achieving quality remained largely defensive Controlling quality still meant acting on defects. Quality was viewed as something that could hurt a company if ignored, rather than a positive characteristics essential for obtaining competitive advantage.

The Emerging Paradigm

Despite the advances made in the "quality revolution," existing approaches are inadequate for understanding or applying management to today's rapidly changing business environment. They are inadequate because they are maintenance oriented (geared to administering existing policies and procedures without changing basic processes or systems) and treat customer value as incidental. What is needed is a more holistic, customer-focused approach to quality. An emerging paradigm, known as **strategic quality management**, incorporates elements of the preceding eras; however, it also views quality as a competitive weapon that should be explicitly addressed in the organization's strategic plans. The essence of this paradigm is a customer value strategy that guides cross-functional systems and ongoing improvement activities.

Customer value strategy is the business plan for offering value to customers. This value not only includes product characteristics and attributes, but also takes a broader view of quality by considering mode of delivery, support services, and cost. The core of this customer value strategy is the belief that providing value to internal and external customers is the key to serving all other stakeholders over the long-term. At Toyota, providing customer value is more than just a service, it is a philosophy that permeates the entire organization. Similarly, the thrust of Xerox's quality improvement program is to make quality improvement, and ultimately customer satisfaction, the job of everyone. In both Toyota and Xerox, the ability to provide value to customers is the basis for policy formulation by the organization. It drives the organization's structure and processes, and therefore the behaviour of its members.

Cross-functional organizational systems are the means that provide customer value. In the emerging paradigm, cross-functional systems are structured to coordinate human and material inputs, process technology, operating methods, streams of work activity, and decision making to optimize the creation and delivery of value to customers. In other words, quality, cost, and scheduling goals are superior to line functions such as design, production, or marketing. Because such systems raise everyone's attention above traditional functional concerns, they break interdepartmental communication barriers and give everyone a more holistic view of the organization and its purpose to serve customers.

Quality, cost, and scheduling goals are superior to line functions such as design, production, or marketing.

One of the formal cross-functional arrangements at Toyota is a board of general managers from each department. The board, known as Jomkai, gets together every few months to set company policies, address issues of research and development, finances, investments, employment, and to discuss improvement programs. The top management of Toyota started this system to address communication problems in the growing organization. The power of such cross-functional systems is that they integrate activities throughout the organization for improvement toward strategic objectives. To keep pace with the changes in the business environment, managers must continually improve the organization. In the past, changes in business strategy were usually episodic. A major technological innovation would suddenly improve corporate fortunes. After reaching a new standard, performances would gradually decay until the next breakthrough occurred, which propelled the organization to an even higher level. Today episodic changes are fewer and they are being supplanted by a continuum of smaller, less dramatic changes. Called **Kaizen** by the Japanese, such incremental changes do not require sophisticated technologies, but instead rely on people to apply simple techniques and some common sense to upgrade the standard of performance.

The emerging paradigm represents an ideal toward which many managers are now striving. Some have tried to move toward this new paradigm by implementing programs such as quality circles, quality improvement teams, just-in-time manufacturing, quality function deployment, and total quality initiatives. Such initiatives sometimes achieve moderate gains, but they usually fall short of expectations. Managers must recognize that piecemeal program implementation will never suffice. Special programs will achieve their full potential only in the context of a broader paradigm shift, which in turn, requires a fundamental change in culture.

Organizational Culture

Nobody knows for sure exactly what culture is, nor will there ever be a universally accepted definition of it. Culture is difficult to define because it means different things to different people. It is an invisible quality—a certain style, a character, a way of doing things—that is often more powerful than any formally documented system or any individual leader. Organizational culture is the key to successfully adopting the emerging paradigm because it influences how we interpret events, shapes our actions, and provides meaning, direction, and mobilization to our lives. It enables us to interact effectively with each other and to behave in expected patterns. An organization is essentially the embodiment of the ideas shared by its members. It reflects beliefs and values that are often referred to as philosophy. It also has axioms that are regarded as self-evident truths. This commonly held body of ideas, values, axioms, beliefs, and assumptions that guide the behaviour of organization members constitutes organizational culture.

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Cultures are formed based on the organization's mission, its setting, and what is required for success (e.g. quality, customer service, efficiency, etc.). When an organization is started, the objectives, principles, values, and behaviours of the founder provide important clues as to what is expected from employees. As organizational systems, policies, procedures, and work rules are formalized, they have a more important impact on shaping the culture. Critical incidents that stem from management action – such as the time so-and-so was reprimanded for disagreeing with the boss – also shape culture as they become the folklore that describe what the organization really wants. In addition, culture develops through a learning process, trial and error experimentation through which members learn techniques that do and do not work in solving problems.

As a culture initially forms it may be very functional. But over time, the culture can become a separate entity, independent of the initial reasons and incidents that formed it. Sometimes a sleeping organization awakes only to find that technology, competition, or some other external event has passed it by – an organizational embodiment of Rip Van Winkle. Such organizations find out that they have lost touch with their mission. And if management attempts to shift the strategy of the organization or tries to adopt entirely new work methods, the power of the culture becomes apparent.

Thus, cultures per se are neither good nor bad. A culture can be an asset if it reinforces the mission, purposes, goals, and strategies of the organizations. If not, it can be a liability. The culture in traditional organizations reflects the influence of the rational view of organizing. Such cultures are based on power and control. People are viewed as expendable parts in a production system. Traditional organizations are also characterized by a high degree of specialization. This requires clear lines of authority and responsibility, which in turn, requires layer upon layer of supervisors to coordinate and control the specialists' activities. The result is usually a tall, pyramidic organizational structure that is slow to respond to changing market demands.

To change from old paradigms to the emerging paradigm requires a culture that is dynamic and filled with constant challenge. It should allow commitment to grow and alienation to decrease. Equally important is the replacement of a climate of low risk-taking with one of innovation. This implies increasing trust and openness in relations, as well as participation, collaboration, and collegiality. All these qualities are mandatory if traditional bureaucratic organizations are to be transformed into adaptive, customer-focused learning organizations.

Cultures that promote the new paradigm are just beginning to evolve, therefore we cannot provide a comprehensive list of all the elements. Even as these cultures develop, it is unlikely that prescriptions could be written for all the elements of an ideal culture. Every organization's culture will be unique according to its own circumstances and history. However, there are common features of cultures that promote the emerging paradigm. Some key principles for these cultures are discussed below.

Customer Focus

Unfortunately, organizations very easily become inwardly focused, with their members seeking to preserve the organization itself rather than accomplish its mission. Such a "selfish" culture is a sure sign of problems. When managers are focused on internal issues more than on their customers, they tend to emphasize functional objectives rather than on how the relationship between functional areas contributes to or detracts from specific aspects of customer value. The primary purpose of organizations should be to provide customer value in order to make money and ultimately survive. Placing customers as top priority assumes that the interests of the other constituents (investor, suppliers, employees) will be better served over the long term. This orientation requires a culture that defines superior customers value as the foundation for group meaning, for serving other constituents, and ultimately for its own survival. Successful companies like 3M, Hewlett-Packard, Johnson & Johnson, Merck & Co., Xerox, and Toyota demonstrate that organizations with external, customer-focused cultures are usually more sensitive to environmental changes and better able to adapt quickly than companies with an internal focus.

Placing customers as top priority assumes that the interests of the other constituents (investor, suppliers, employees) will be better served over the long term.

Optimizing Organizational Performance

Another characteristic of cultures that support emerging paradigm is a focus on improving the processes and systems that provide customer value, rather than on quality itself, functional results, or people. Everyone must understand that quality, productivity, and customer value are by products of the effort extended to improve and integrate organizational systems. Because they are by-products, they can not be specifically worked on. In addition, when employees throughout an organization think in terms of process and system improvement for customer value rather than just functional objectives, the diverse functional subcultures present in many organizations may start to blend. As each group assimilates the superordinate values of a customer orientation, integrated efforts among functions become more strategically purposeful.

Quality, productivity, and customer value are by-products of the effort extended to improve and integrate organizational systems.

Many organizations devote considerable resources to training employees. Frontline workers receive training in everything from basic literacy to statistical process control. Managers may also be taught planning and organizing strategies, leadership techniques, and interpersonal skills. Such improvement of the knowledge and skills of the workforce is important, but many of these efforts are focused on fixing special cases or problems and not on systematically building work force capabilities to improve processes or systems. Such approaches implicitly assume that individual employees, not larger systems, are primarily responsible for performance problems. Managers in the new paradigm assume that performance problems are due to organizational systems, not just employee attitudes or skills. This assumption is reflected in the responses of supervisors to performance problems-initial questions are asked to identify root causes of problems in business processes and systems rather than in determining who to blame.

Openness to New Information

This value is reflected in employees seeking to continually improve processes and systems. Suggestions for improvement are welcomed, discussed, and tested, and ongoing experimentation on cause and effect is conducted to test and supplement intuitive and experimental efforts. However, when people experiment with alternative courses of action, desirable results do not always occur. In the new culture, mistakes are not desirable, but they are viewed as opportunities for learning.

To support such efforts, employees must receive training in systematic data collection and must have the analytic tools and resources available to them to improve things. Furthermore, completing training and offering suggestions must be recognized and rewarded. Managers must also realize that simple devotion to customer satisfaction will not suffice. It is easy for managers and employees to assume they already know what customers value and that they can decide whether the product is good enough to satisfy customers. But in a culture that supports the emerging paradigm, employees go beyond their own understanding and try to confirm it with actual customers. Toyota's Customer Relations Department uses a survey system to obtain feedback from customers. Toyota managers also display an uncompromisable commitment to understand the customer's entire use situation. A great deal of hands-on learning is led by chief engineers and their staff as they visit dealers, talk to service managers, salespeople, and customers. They get a firsthand assessment of how each model has been accepted by customers and use this information to plan future models.

Continuous Improvement

In many organizations people work to specification and feel that if their work is within specifications or standards, it should be accepted as satisfactory. The expression "if it ain't broke, don't fix it" epitomizes this approach to management. Continuous improvement goes beyond simple problem solving by assuming that something is "broke" if it has any variation that can be reduced around the target desired by customers. This becomes progressively more difficult as the more obvious improvements are made and more challenging issues remain. However, by enhancing the organization's capability to deliver valued products and services, new standards of excellence can be continually set, this raising customer expectations to increasingly higher levels.

Part of what drives continuous improvement at Toyota is the high level of aspirations set by managers. Toyota does not expect to get to the top all at once. Rather, managers continuously set more challenging standards that keep people motivated to improve. Paradoxically, Toyota employees remain in a permanent state of dissatisfaction trying to improve customer satisfaction. Employees continuously challenge existing standards, make changes for improvement, and then standardize the changes. They also continuously seek to identify areas of weakness, while also raising their own levels of aspiration. Thus Toyota's pursuit of perfection is relentless.

Employees continuously challenge existing standards, make changes for improvement, and then standardize the changes.

Leadership

In the emerging paradigm, top managers must provide direction for the organization by communicating to the employees a common vision for superior customer service. Through their behaviours, top managers must also create the type of organization that can continuously improve customer satisfaction from the bottom up as well as top down. At Toyota, leaders exemplify their commitment to providing the best customer quality through their actions. They also make sure employees have the necessary resources to fulfill their responsibilities and to realize the vision. This kind of leadership empowers employees to do what they know is right for the organization as a whole and its customers, while recognizing that empowerment without enablement is a lie.

Employees in such a culture exhibit a strong sense of personal responsibility for individual contribution to broader systems and organizational purpose. At Toyota, this means that everyone does whatever is necessary to get the job done. When people feel a strong sense of personal responsibility, they are reluctant to ascribe personal blame for mistakes and failures. This does not mean that there is a repression of mistakes, only a repression of pinning if on an individual. Managers at Toyota strike a balance between personal and team responsibility, with individuals prepared to assume personal responsibility, yet reluctant to cast blame on others. This tendency makes it easier for people to work together to fix whatever is wrong and to make other improvements.

Teamwork

Such a sense of personal and team responsibility helps to establish effective teamwork across hierarchical levels and departments. Teams are the cornerstone of quality improvement at Xerox, and teamwork is built upon a foundation of human relationships informally built among the members. Because of the potential of teams to accomplish more than the individual members working separately, Xerox has focused on cross-functional teams responsible for improving the basic processes and outputs that have a significant impact on business. With a mandate to reduce errors and cycle time to improve customer satisfaction, teams are given wide latitude to do whatever has to be done. Xerox also provides the teams with "planned learning experiences" rather than just training and education courses. The level of knowledge and skill of the team is taken into account, so the learning experience is adjusted to fit team member needs. Tools and techniques are provided as needed, just in time to be applied to a process.

A sense of personal and team responsibility helps to establish effective teamwork across hierarchical levels and departments. Teams are the cornerstone of quality.

Changing Cultures

Shifting to a new culture will mean different things for different organizations. To the extent that the current organizational culture is already compatible with the concepts and practices of the emerging paradigm, the shift will be much easier. It generally takes a long time to change old habits, and the shift cannot be made all at once. Everyone must learn new ways of thinking and acting, discovering for themselves what works and what does not work. Furthermore, if the entire organization is to act in concert, the members have to arrive at some social agreement about what works and what does not. This kind of cultural learning can take years. And just like the inertia for physical objects, the bigger the organization, the more difficult it will be to make the shift. But it can be done.

There has been considerable debate regarding how managers should develop the type of culture that supports the emerging paradigm. Some (e.g., French, Bell & Zawacki, 1983) have argued that we should initially focus change efforts on the deepest levels of culture by bringing to the surface the underlying assumptions and values that guide members' behaviour. Others suggest that successful corporate revitalization tends to begin in individual units, often moving from remote and relatively isolated units into the corporate core (Beer, Eisenstat & Spector, 1990). Fortunately, many people now recognize that the problem of cultural change is more complex than either of these approaches. But this chicken and egg issue remains a puzzle for managers seeking to transform organizations and highlights why they must have a clear understanding of culture.

Research and practice have not demonstrated any one formula for successful cultural change. But the key seems to be top management persistence on learning how to make the new customer-focused strategy operational. Change must be driven by the competitive business needs of the organization. People must be placed in new roles that require them to rethink how they function and reinvent how they work. Thus, the levers of change are to be found in the roles people play throughout the organization and in the methods, tools, and systems that provide the working content of these roles. Using these levers to produce a new organization, and ultimately a new organizational culture, is something of an art.

Beyond Total Quality Management

Quality has evolved from a discipline relegated to inspectors and technical experts to a strategic focus and a process oriented approach that commands the attention of all employees, from the CEO to the front line workers. To go beyond Total Quality Management implies that "quality" should not be implemented in the form of various programs. In too many organizations, managers regard quality efforts as a sideline activities—corporate programs which require a few hours each week. In such organizations, collateral activities are established apart from the normal managerial process, rather than blended in as a way of life. Additionally, managers often mistakenly believe that the use of certain tools and techniques constitutes total quality management, a belief often associated with the program mentality. As organizations go beyond total quality management, the fundamental principles of the emerging paradigm become a natural part of the organizational culture, rather than something that employees are preoccupied with implementing or worried about putting into place. Organizational practices unconsciously flow from the fundamental principles ingrained in the culture, taken for granted as the assumed way of doing business. In this sense, the emerging paradigm becomes central to every employee's role and not an extra duty that requires conscious attention and directed effort.

As organizations go beyond total quality management, the fundamental principles of the emerging paradigm become a natural part of the organizational culture.

References

Beer, M., Eisenstat, R.A., & Spector, B. (1990). *The critical path to corporate renewal.* Boston, MA: Harvard Business School Press.

French, W.L., Bell, C.H., & Zawacki, R.A. (1983). *Organizational development: Theory, practice, and research* (Revised Edition), Plano, TX: Business Publications, Inc.

Garvin, D.A. (1988). *Managing quality: The strategic and competitive edge.* New York: The Free Press.

Kuhn, T.S. (1962). *The structure of scientific revolutions.* Chicago, IL: The University of Chicago Press.

Shewhart, W.A. (1931). *Economic control of quality of manufactured product.* New York: D. Van Nostrand Company. □

Management of Change

Workers who seek meaning, who question authority, who want to exercise discretion, or who demand that their work to be socially responsible may be regarded as trouble makers today. In future, industries cannot run without them.

— Alvin Toffler