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Indian Automotive Industry: Challenges & Prospects

Sunil Chaturvedi

This paper discusses the challenges and prospects of the Indian Automotive Industry. It also focuses on the performance of passenger car Industry and Auto Component Industry.

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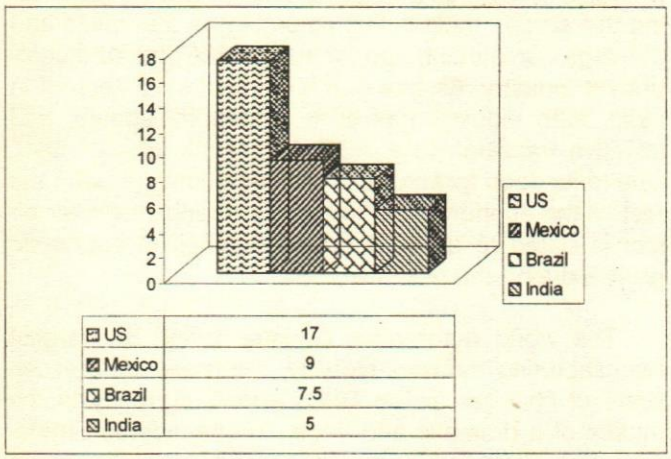
The Indian automotive industry is witnessing a defining moment. More than six decades after its inception, the industry is on the threshold of a major leap forward. Increasing scales and depth, considerable product variation and increasing acceptability of Indian products in regional and global markets are largely driving this surge. India is fast emerging as a credible and the large outsourcing hub for automobile and auto component industry. As one of the key industrial sectors in India, auto industry has seen a smooth, speedy and effective transition to a WTO compatible environment. Due to its deep forward and backward linkages with the rest of the economy, the industry's strong multiplier effect is slated to usher in added notches of economic growth during the next few years.

The world automotive industry, being the largest manufacturing industry globally, witnessed unforeseen scale of changes in the 1990s and is currently in the middle of a dramatic and largely unprecedented transformation. Globalisation and the spread of the information revolution has vastly enhanced mobility, directly accelerating the spread and growth of the automobile industry across nations, though more pronounced in developing economies. Simultaneously, rising consumer and community expectations in relation to vehicle quality, safety and environment related performance parameters are paving the way for stringent regulatory standards. These, in turn, are driving major technological developments in product and process formats. In the emerging environment, India has major challenges as well as advantages few others in the world can match.

Growth of Automotive Industry

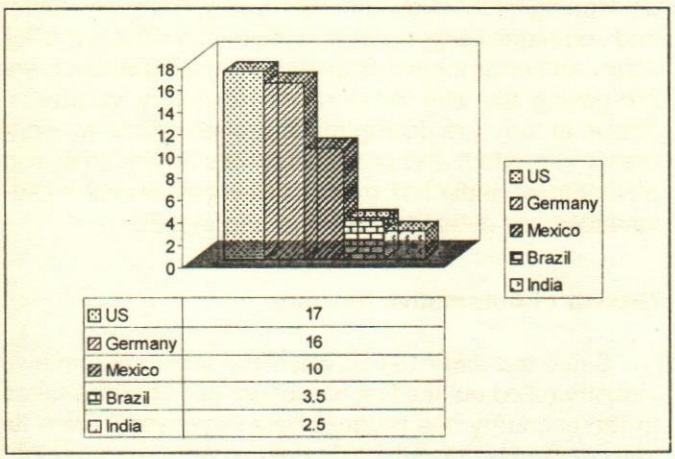
Since the early 1940s, when the Indian automotive industry rolled out the first passenger car, its significance in the economy has progressively increased. From its early days until the mid-1980s [for two wheelers and Light Commercial Vehicles (LCVs)], and until the early 1990s

[for passenger cars], the focus of development of the automotive industry was on import substitution. The current low penetration levels in India in all three segments of the industry, namely Commercial Vehicles, Passenger Cars and Two Wheelers, and the gross under-exploitation of the potential of this industry has resulted in the auto industry hitherto contributing a relatively low (nearly 5%) share of industrial output in India compared to the 8-10% in other developing countries such as Mexico and Brazil and much higher (in 15-17% range) in developed countries such as USA and Germany. Even the share of automotive industry in overall industrial employment stands low at 2.5%. Comparatively, this share stands at 3-7% in other comparable developing countries, and around 15% in mature economies (see Exhibit-1 and 2). Developed countries such as USA, Japan, as well as newly industrialised countries such as Korea and Thailand, have effectively used the auto industry as an engine of growth.



US	17
Mexico	9
Brazil	7.5
India	5

Exhibit 1: Auto industry's output as a percentage of overall industrial output



US	17
Germany	16
Mexico	10
Brazil	3.5
India	2.5

Exhibit 2: Auto sector employment as a percentage of overall industrial output

The auto industry in India has shown great advances since the abolition of licensing in 1991 and the successive liberalisation of the sector over the years (Table 1). The freeing of the industry from a restrictive environment has, on the one hand, helped it to restructure, absorb newer technologies and align itself with global developments, on the other hand, this has significantly increased the industry's contribution to overall industrial growth in the country. The Indian automotive industry is now inhabited by global players in keen competition, making it the third largest car market in Asia, second largest two-wheeler producer, and fifth largest commercial vehicle producer in the world.

Table 1: Milestones in Policy Framework

Up to 1991	Automobile Sector remains within the confines of licensing.
July 1991	Licensing abolished and automatic approval permitted up to 51% foreign investment in priority sectors that included the automotive industry, except passenger car manufacture. The foreign equity was to match the outflow on import of capital goods; dividends repatriated were to be balanced by export earnings.
1992	Government rescinded the stipulation of balancing the repatriation of dividend except in the case of consumer goods and motor cars. These were freed from the stipulation only in July 2000.
April 1993	Motor car manufacture was freed from licensing
1997	Press Note No. 60 was issued on 12-12-97 by the Ministry of Commerce. New joint venture car manufacturers desiring import of components for motor vehicles in CKD/SKD form restricted for import under the current Exim Policy were to execute a Memorandum of Understanding (MOU) which stipulates that the foreign investor shall, • Establish actual production and not merely an assembly facility. • If the joint venture involves majority foreign equity ownership, a minimum foreign equity of US $ 50 Million is to be brought in by the foreign partner. • Regulate the import of CKD/SKD components to achieve a level of indigenisation of 50% in the third year and 70% in the fifth. • Neutralise foreign exchange outgo on imports with export of cars components, etc.
October 1997	Automatic approval for foreign equity investment upto 51% for manufacture of motor cars was extended.
February 2000	Automatic approval for FDI/NRI/OCB investment was permitted save in exceptional cases.
April 2001	Quantitative Restrictions removed. Regulations regarding local content in manufacture and export obligation no longer applicable. Automotive vehicles of all categories freely importable.
March 2002	New Auto Policy announced. 100% FDI permitted in Auto sector. Minimum investment threshold taken off.

There are 15 manufacturers of passenger cars and multi-utility vehicles with more than 150 on-road models

and variants, nine manufacturers of commercial vehicles, 14 of Two/Three Wheelers and 14 of tractors, besides five manufacturers of engines. The total investment in the industry has now crossed US $10 billion, with annual turnover exceeding US $ 16 billion. The industry employs more than 11 million people and contributes more than 17% of the total indirect taxes.

A robust manufacturing capacity has been installed by the industry in India over the last two decades (Table 2). Its utilization, however, has been sub-optimal till now as a consequence of initial over-estimation of market potential. This again mirrors the global industry position.

Table 2: Installed Capacity in Different Segments in Units

Segment	Installed Capacity
Four Wheelers	1,500,000
Two & Three Wheelers	6,400,000
Total	7,900,000

Four Wheeler capacity is inclusive of passenger car manufacturing capacity of 1,237,000 units

A Glimpse at the Industry's Performance

Production of various categories of vehicles during the last five years (Table 3) represents a progressively increasing utilization of installed capacity in the range of 65-80%. The arrival of new and contemporary models has stimulated demand. The industry as a whole achieved a cumulative annual growth rate (CAGR) of 22% between 1992-97. This led to an increase in the industry's contribution to industrial output from 4.3% in 1992-93 to 5.4% by 1996-97. Barring 2000-01, consistent growth in different segments has continued, with a remarkable leap in the current year (April to October). Passenger cars in the current year have shown a growth of 35.87%, Multi Utility Vehicles (MUVs) of 28%, Commercial vehicles of 29%, Two Wheelers of 8.37% and Three Wheelers of 17.17% as compared to the corresponding period of the previous year.

The Indian automobile industry has witnessed a paradigm shift in quality and technology in products and services during the eighties and nineties. While this has been largely driven by foreign manufacturers bringing in technology and quality standards prevalent in Europe, it would be necessary to acknowledge the arrival of several Indian products that have received international acclaim for quality and reliability. Passenger vehicles from Tata and Mahindras are successfully competing with multinational products, domestically as well as globally. This conjures up an image of a fast maturing, globally competitive manufacturing regime in the Indian automotive sector.

Table 3: Production of Different Categories of Vehicles in Units

Category	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04*
Passenger Car	390709	577243	513415	564052	606088	413095
Multi Utility Vehicles	113328	124307	127519	105667	11488	1112751
Commercial Vehicles	135891	173521	156706	162508	202946	139233
Two Wheelers	3374508	3778011	3758518	4271327	5109419	3201279
Three Wheelers	209033	205543	203234	212748	271224	183984
Total	4223469	4858625	4759392	5316302	6304558	4050342
Percentage Growth	5.40%	15.00%	(–) 2%	11.70%	18.60%	12.10%

* Figures relate to April-October 2003.

Table 4: Exports of Different Categories of Vehicles in Units

Category	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04*
Passenger Car	25468	23271	22990	50088	70547	62957
Multi Utility Vehicles	2654	5148	4122	3077	1106	2417
Commercial Vehicles	10108	9912	13770	11870	10704	7948
Two Wheelers	100002	83272	111138	104183	179568	142263
Three Wheelers	21138	18388	16263	15462	43443	39004
Total	159370	139956	168283	184680	305368	254589
Percentage Growth	(-)16.63%	(-)12.18%	20.24%	9.74%	65.35%	56.95%

* Figures relate to April-September 2003.

That the Indian automotive industry is finding increasing recognition worldwide is evident from the impressive pace of growth in exports over the last few years (Table 4) although in terms of volume, these are still small.

Major Trends in the Automobile Industry

Several distinct trends are visible in the worldwide automotive industry, which are also finding reflection in India. Globalization is pushing auto majors to consolidate, to upgrade technology, enlarge product range, access new markets and cut costs. They have resorted to common platforms, modular assemblies and systems integration of component suppliers and e-commerce. 'Systems supply' of integrated components and subsystems is becoming the order of the day. This process has unleashed a speedy 'tierisation' of component industry globally. Over the 1990s, the total number of component suppliers world-wide fell from 30,000 to just 8,000, representing major forces of rationalization as a result of cost pressures.

Reflecting increasing sophistication of the auto market, sub-segmentation of each segment is taking place. Passenger cars, two wheelers and LCVs have seen a number of models and variants in the last decade to suit each portion of the market. A supplier driven market that was ruled by a handful of models and variants in various segments two decades ago, now, has more than 150 models and variants competing for attention. The average life of a passenger car model is now assessed at 5-6 years before it suffers 'customer fatigue'. Thus, Original Equipment Manufacturers (OEMs) are constantly enlarging their stable of models in the Indian market.

Use of electronics and informatics is increasing fast, indicating sophistication in construction of vehicles. Electronically controlled braking and steering systems ('drive by wire') are making larger testing procedures redundant while improving vehicle efficiency, fuel economy and safety profile of the vehicles. Higher end vehicles today carry electronics representing as much as 40% of vehicle cost. This trend offers a major opportunity for India with its significant strengths in IT and electronics.

Volumes are key to the automotive industry in India as anywhere else in the world. However, the industry's penetration in India is relatively shallow. For example, India has a passenger car penetration of 6 per thousand. With a production level of 700,000 cars per annum, India is ranked 15th, behind USA (15 mn), Japan (7.5 mn), Germany (5.3 mn), France (3.6 mn), South Korea (3 mn), Spain (2.7 mn), Canada (2.6 mn), Mexico (1.7 mn), Brazil (1.7 mn), UK (1.8 mn), Italy (1.3 mn), China (1.2 mn), Russia (1.1 mn) and Belgium (1 mn). Volumes in all segments of the industry hold the key to technological self-reliance, which in India has not been possible till now due to inadequate growth in domestic demand and hitherto low exports.

Environmental and safety concerns are leading to the emergence of higher safety and emission standards in the country. This is leading to manufacture of world-class vehicles in India while impacting the bottom-line of OEMs due to their inability to pass on added costs to a price-sensitive market.

A certain degree of maturity is now ascribed to the Indian automobile market, especially in the passenger car and two-wheeler segments, in as much as the traditional exclusive price sensitivity is slowly giving way to price-value awareness. In some way, the dominant basis of competition is gradually changing from price to the price-value concept. However, this is yet to emerge as a dominant market feature.

Environmental pollution and the need to conserve the existing supply of fossil fuels have led to a search for alternatives. There is wide realization of the need to support development and introduction of vehicles propelled by energy sources other than hydrocarbons. Fuel Cell technology, which principally involves the use of hydrogen to produce electric current is slated to increase the market potential of electric vehicles. Battery powered vehicles, on the other hand, hold major promise in the midst of urban transport challenges. It has been estimated that by 2030, more than 50% of vehicles will be powered by fuel cells globally. India's tryst with fuels like CNG in Delhi has been globally hailed but suffers limitation in terms of limited spread. Greater use of lightweight materials such as plastics, aluminium and magnesium. is being increasingly preferred.

By 2030, more than 50% of vehicles will be powered by fuel cells globally.

Excess capacity arising out of the rush to invest in developing economies, coupled with overestimation of demand in these markets, continues to haunt the Indian industry like its global counterpart. Global auto experts expect the situation to abate only around 2008-10 with sustained, large capacity use.

Within the limited scope of this paper, an analysis of segment-wise detailed trends in the global and Indian automobile industry is not possible. However, to illustrate the type of micro developments taking place in

a significant segment like the passenger car industry, select facts are given in a snapshot in Exhibit 4.

Indian Auto Component Industry – Structure & Performance

Robust growth in the automobile industry during the nineties has created significant opportunities for the auto component sector in the country. Responding to the emerging scenario, the Indian auto component sector has shown great advances in recent years in terms of growth, spread, absorption of newer technologies and flexibility, despite the multiplicity of technology platforms and low volumes. India's reasonably priced skilled workforce, large population of technology workers coupled with strengths gained by the country in IT and electronics all build up an environment in which a significant leap in the component industry is possible. The Indian auto component sector is being written up as the next industry, after software, that has the potential of becoming globally competitive.

The Indian auto component industry is wide (over 400 firms in the organized sector producing practically all parts, and around 10,000 firms in the small unorganized sector, in tierized format) and has been one of the fastest growing segments of the auto industry, growing by over 28%, in nominal terms, between 1992-98. After a lull following global economic slump, the component industry's growth rate has bounced back to 17% with exports galloping to 37% in 2002-03. Significant growth in this segment has been primarily triggered by impressive strides made by the auto industry itself over the last two decades. The investment made by nearly 400 organized units now exceed $ 2.3 billion. The component industry directly employs about 350,000 people, and its annual output is currently pegged at $ 5.5 billion. Annual component exports, now valued at $ 800 million, represent only about 0.08% of the global component trade, currently estimated at around US $ 1 trillion. This is reflective of significant opportunities that lie ahead.

The component industry in India is, however, relatively very small in scale, and is highly fragmented in comparison to the size and scale of the industry in other countries around the world. Of the 400-odd component manufacturers in the organized sector, only 30 have revenues higher than Rs. 150 crore. Two-thirds of the industry's players are smaller than Rs. 50 crore. Less than 15 companies have exports of over $10 million. India's component industry is smaller than the annual turnover of a number of global component manufacturers (Visteon had a global revenue of US $ 20 billion in 2002). Also, in 1993-94, the number of firms in the industry were around 6,350, of which, 94% were in the small scale. The figure is now expected to have reached around 10,000. These findings point out that, barring a few, most units are tiny to small, and are consequently dependent on other firms and institutions for their growth, or even survival. These small enterprises are also driven by their circumstances to cater to the replacement market only. This structure, though it facilitates lower costs, does not discourage low productivity, which was considered 60-75% of the international levels in the year 1998-99.

Several significant challenges inhibit the growth of the component industry, for instance, lower volumes, fragmentation, inadequate R + D / technology support, lower productivity levels, limited resources for international marketing and establishment of an efficient supply chain. Two significant challenges facing the component units today are, diverse technological platforms to service and very low volumes. Due to diversities in the technological profiles of OEMs hailing from Japan, USA, Germany, Korea, Italy, the Czech Republic and several other European countries, the sector today comprises a large variety of component types, each having different requirements, technologies and consequently, minimum size of operation. An analysis of the members of Automotive Component Manufacturers Association of India (ACMA) having annual turnover of less than Rs 8 crore (US $ 1.6 Million) reveals several interesting patterns of inter-firm linkages and consequent performance. This study broadly pointed to a critical level in terms of size (i.e. sales and employment) that enables a unit to become a viable supplier to OEMs. It is suggested that to be able to become an OEM supplier, a firm needed 60 to 100 employees and a sales level of Rs 1 crore (US $ 0.2 Million). The largest cluster of OEM suppliers was found to have sales that range from 1 - 4 crore (US $ 0.2 Million to 0.8 Million). It was concluded that exports distinctly picked up once a firm reached this threshold. Incidentally, these were the firms qualifying as tier 1 suppliers, and which produced larger varieties of component assemblies as opposed to the narrower range of products being produced by relatively smaller firms. This structure of the component industry inhibits innovation, R and D, higher productivity and consequently snuffs competitiveness.

To become an OEM supplier, a firm needed 60 to 100 employees and a sales level of Rs 1 crore.

The situation of lack of competitiveness, which further led to low investments, dependence on outdated technology and low quality manufacturing is, however,

witnessing significant transformation over the last few years. Global technologies, which streamed into India with major vehicle manufacturers, have brought marked changes in the Indian component industry. This exposure has had a salutary effect on shop floor practices, inventory management, quality consciousness and individual productivity. Concepts of Six Sigma, TQM, TPM, Just in Time Manufacturing, lean manufacturing, etc. are no more alien to any medium size Indian component manufacturer. There are several reasons for this phenomenon but the most important one has been the change in the focus of innovation, which has moved from product innovation to process innovation. All this is leading to the Indian auto and auto component industry receiving global attention in terms of outsourcing from India.

The pace of growth of the auto component industry, notably during the last three years, has been impressive. Its turnover has more than tripled in the last eight-year period, as the year-wise turnover would indicate in Exhibit 3. This has been despite crippling problems of low volumes due to multiplicity of OEMs, vehicle models and variants, all requiring large number of parts in small quantity. This acute diversity of the market has appreciably been used by the Indian component industry to hone its capabilities, increase its focus on quality and reliability and come up in a great measure to global qualitative standards. Of the 421 large component producers, 337 have ISO 9001, 42 have ISO 14001, 195 are QS 9000 certified, while five have received the globally coveted Deming prize. An increasing number of component manufacturers are attaining zero ppm (zero parts per million) rejection rate on international supplies flowing to OEMs as against a rejection rate of 20,000 to 30,000 witnessed a few years ago.

Quality consciousness is now leading the Indian component manufacturers into the global supply chains. In 2001-02, 13% of the component industry's output was exported, while in 2002-03, it has gone up to 15%. More significantly, as much as 56% of exports are to the USA and Europe, which are considered highly sophisticated and quality conscious markets. An export growth of 20% (CAGR) witnessed during the 1990s has given way to a robust 37% jump in 2002-03, with more encouraging trends being witnessed during the current year. Industry estimates place 2003-04 component exports at close to US $ 1 billion.

An export growth of 20% (CAGR) witnessed during the 1990s has given way to a robust 37% jump in 2002-03.

Dominant Trends in the Indian Component Industry

It is said that the global automotive component industry is in 'ferment' today. Manufacturing is shifting to find the most economic and efficient location. The new requirements in the auto and component industry are being driven by a variety of agents that include vehicle manufacturers, new legislation, availability of efficient and skilled manpower at competitive rates and locational advantages. Several new trends are discernible in the global auto component industry. Some of these trends are:

(a) Cost pressures in the automobile industry have stimulated the development of more complex components, especially in the passenger car segment; e.g. a definite trend in terms of electronics embedded in modular parts is emerging. Advanced cars already have more than 40% of their value in electronics.

(b) Stricter regulations relating to safety, emission and performance, are leading to the development of new products and processes; continuous innovation holds the key to sustenance.

(c) 'Tierisation' of the component industry is spreading around the world, with automobile manufacturers broadly turning into efficient assemblers and component manufacturers at different tiers; producing a broad band of items from isolated components to assemblies and sub-assemblies;

(d) Supply chains are getting vastly restructured. Vertical integration (vehicle manufacturers manufacturing major components in an integrated plant) is on the decline due to cost pressures and increasing complexities of each individual component. Outsourcing at the global level is, thus, becoming a reality and an economic option. There is also an emerging trend of reduction in number of companies that supply directly to vehicle manufacturers, showing the supply base into a sort of pyramid, and delegating some of the routine tasks of purchasing, production scheduling and inventory management to their 'Tier one' suppliers.

(e) Vehicle assemblers are increasingly asking for sub-assemblies and solutions to their problems rather than finding individual suppliers, thereby expecting suppliers to have product development capabilities

(f) Some very large component manufacturers around the world like Delphi, Nippondenso, Rockwell, Lucas, Bosch, TRW, Calsonic, etc. (a few of these are larger than some car as-

semblers) are establishing operations in emerging markets, primarily to take advantage of more economical manufacturing. However, the growth of the component industry in India has only limited reflection in terms of relocated manufacturing capacity.

(g) OEMs are moving deliveries from monthly to weekly to bi-weekly, daily or even to more than one designated time slot everyday. Coupled with this is the stress on world-class quality. Thus, the only option for auto component manufacturers is to improve their productivity on the shop floor.

(h) Car assemblers are increasingly "carrying" their suppliers with them to newer locations; and

(i) Markets in developed economies are getting saturated.

The Indian Component Industry – Opportunities & Challanges

The current trends in the automotive industry have sprung up major opportunities as well as challenges for the auto component industry in India. India's potential to become a major global outsourcing hub for automotive components is strengthened by certain inherent advantages that include:

- Availability of skilled and semi-skilled manpower resources at competitive cost.
- Huge metal based natural resources that can support metal intensive manufacturing activities.
- High quality technology and software oriented design and engineering skills that can result in high value addition.

However, to avail these opportunities, the industry has to migrate from the conventional mode of operations. The current focus of a large number of small firms on low value products, due to small investments and lower scales of operations, limits their capability to meet the emerging competitive challenge and benefit from the opportunities emerging from the tierisation process currently underway. While this cannot undergo change in the short term, a correct move in this direction would be towards improving manufacturing capabilities of small and medium auto component firms, their standards of quality, and investment in training. It is clear that unless they make significant investments in capability building, they will be either competed out by large firms (some of which are being set up by large auto component multinationals), or relegated completely to the replacement market, as the requisite standards for the OE market will not be met by them. It must be recognised that while the replacement market is large and growing, the segment for small low capability auto component firms will gradually shrink, as newer models (embodying newer technology) will replace the older models.

While the replacement market is large and growing, the segment for small low capability auto component firms will gradually shrink.

Large component manufacturers with global linkages are coping well with speedy changes but there are serious difficulties before small and medium component manufacturers. However, it is this contingent of small and medium component manufacturers that holds out a major promise for the country. They can, with appropriate support and handholding, develop into meaningful players domestically and globally. It would, however, be necessary to categorically identify their constraints and strategize timely and appropriate intervention for addressing these constraints. A number of recent studies have shown that some of the key challenges before the small and medium auto component firms relate to

- Quality and Technology
- Knowledge, Awareness and Productivity
- Domestic and Global Linkages

To address these issues in the medium term, the following specific measures have been debated:

- Enhancing manufacturing capabilities, i.e., improve quality (of product & process), reduce costs, reduce lead times etc.;
- Developing and sustaining a continuous focus on quality consciousness and quality improvements; internal benchmarking with periodic reviews.
- Upgrading equipment and acquiring advanced technical knowledge in key areas such as precision tooling, castings, forgings and finishing, precision machining, etc.
- Facilitating availability of adequate testing, validation and R&D infrastructure, preferably on a common platform.
- Developing awareness about fast changing

trends and technologies in domestic as well as global markets, and devising ways to suitably adjust to such trends.

- Improving managerial and technical capabilities of employees; enhancing their focus on productivity and quality.
- Building national and international alliances with specific provisions for learning, timely payments, and credit;
- Building linkages to improve the distribution network and for better market access; and
- Developing mechanisms to facilitate identification of good quality products and production units.

There is an urgent need to bridge the gap between potentially feasible capability levels and the actual levels attained in Indian auto component firms. In fact, the difference between an average firm and the frontier firms operating in the same component segment are also very high. This keeps the average firm almost consistently out of the mainstream market.

The Indian component industry is undergoing substantive changes in its structure, albeit at a pace slower than warranted for its healthy growth and international alignment. From the fact that the removal of localization requirements by the government in 2001 has not made any adverse impact on this segment, and that an increasing number of OEMs seem to be convinced of the economics of local sourcing of components and assemblies, it should be construed to represent a stable, deep-rooting of this segment in India. Component manufacturing is a scale driven industry and needs rapid technological up-gradation. Thus, quality consciousness and adoption of best global standards alone would ensure its survival in global supply chains. The industry seems to be striving to achieve this objective.

In the current transition, SMEs will need facilitation on some key constraints faced by them to sustain in a market driven by speedy innovation and cost effectiveness.

Relationship with global tier-I suppliers alone will ensure scales of operation critically needed for long-term survival and growth. With the distinct IT advantage available in India, the component sector can actually leverage its low costs to attain major global advances. SMEs have a critical role to play in this venture. With timely collaborative efforts, this industry can smoothly grow to around US $ 12 billion with 25% of output geared for exports by the year 2009-10.

The Indian Automobile Industry: The Way Forward

The growing significance of the auto industry in the national economy led the Government of India to announce a separate Auto Policy in March 2002. The policy, inter alia, aims to conduce incessant modernization of the industry and steer India's software industry into automotive technology. Its stated objectives also include making India an international hub for manufacturing small, affordable passenger cars and a key centre for manufacturing tractors and two-wheelers. Small cars hold great promise not only in India but in entire south east Asia due to the geo-demographic features of the region. The Government of India has already started taking proactive initiative on some of the key policy prescriptions. National highways are under major upgradation, providing a significant fillip to the automobile industry. Automotive testing facilities are proposed to be upgraded with an investment exceeding Rs. 1500 crore. Incidence of excise duty on passenger car has been reduced in the last budget, and body building in the commercial vehicle segment is being rationalized to conform to safety standards. India has also joined the Global Forum for Harmonization of Automotive Standards or the WP-29, a United Nations outfit, in its pursuit to further align Indian standards with global ones, paving the way for smoother exports from India. All these steps have created considerable enthusiasm in the industry.

The Working Group on the Automotive Industry, set up by the Planning Commission (WG) in 2002 to project the automotive industry's growth during the Tenth Five Year Plan period (2002-2007), in their report indicated a major growth prospect in the automotive sector in the next 5-6 years period. WG has estimated a 300% increase in the automobile industry's turnover by 2010, taking it to Rs. 1,86,836 crore. In the auto component industry, the WG has estimated a turnover of around Rs. 66,000 crore by 2010.

Some positive developments are already in sight. Indian vehicles have started gaining the confidence of several sophisticated markets of Europe and the Americas. Passenger cars and two wheelers are being exported to more than three-dozen countries across continents. Some Indian two wheeler manufacturers are also taking over manufacturing capacities in other south east Asian countries like Thailand and Indonesia.

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The component industry is also upbeat on the emerging prospects. The Automotive Component Manufacturers Association (ACMA) has indicated that Indian component exports of US $ 800 million, which currently account for only 0.08% of the US $ 1 trillion global component trade, should reach up to 3-5% in the next few years with appropriate policy framework. There are several large Indian component manufacturers, who are moving beyond national boundaries to have a foothold in global trade. For instance, Bharat Forge Limited, the largest Indian component manufacturer, has gained a major foothold in the Chinese market. They have recently taken over CDP, a forging company of Germany, making them the world's second largest forging giant. It is estimated that component outsourcing from India should increase to US $ 1.3 billion in the next two years. Several auto giants have set up their regional R&D centres in India. Traditional IT centres like Bangalore are also emerging as hubs for IT and electronics integration into auto parts. Electronics embedded automotive components are driving large outsourcing from India. India is credited with a major potential for conceiving, designing and manufacturing innovative Intelligent Transport Systems (ITS) which are expected to provide answers to some of the most crucial transport related problems of the world.

Global Automobile Hub: Indian prospects

As the quest for mobility across villages, cities, nations and continents increase, the automotive industry's prospects are slated to shimmer irrespective of its location. In the world's struggle to devise the most economic and efficient vehicles with the least possible damage to the environment and to run on renewable energy sources, India's inherent strengths of large technically qualified human resource, its unmatched advances in information technology, its vast reservoir of essential minerals and metals together with varied flora and fauna, climatic conditions and bio-mass will greatly aid it's initiative in the transport sector. This will also require a sustained, constructive and collaborative Government-Industry partnership in the medium term to ensure a stable fiscal regime and proactive encouragement to India based R&D efforts.

Domestic demand for automobiles in India is unlikely to see a dramatic rise in the medium term keeping in view the pace of socio-economic changes. With volumes being key to the automotive industry, a major breather, therefore, rests in competitive and qualitative exports. Despite global over-capacity, India can have an edge and an aggressive presence in two-wheeler and small passenger car segments together with world-class components in the regional and global markets by offering the most economical manufacturing base with world-class human and technological inputs.

The 'Made in India' brand in the automotive sector, especially in the auto component sector, has travelled a long way from being an object of low credibility to an object of preference in several key regional and global markets. 'Made in India' products are, however, only replacing old suppliers in these markets with cost economics as the driving force. They are yet to make a mark as 'alternative designs' and 'more intelligent' solutions, and in that sense they are yet to be imbued with Indian strengths on a large scale. This requires sustained R&D primarily by the industry, with collaborative efforts from the government. In this context, government's proposed project for setting up state-of-the-art, globally competitive testing, R&D and validation facilities in five years time gains significance. This will also require handshaking of academia and the national laboratories with the industry. A Core Group on Automotive R & D (CAR) set up by the government recently has taken this initiative further.

With all this, the stage appears set for the Indian automotive industry to gain its rightful position in the domestic economy and global trade. The Auto Policy's objective of making India a global automotive hub does not appear a distant dream anymore.

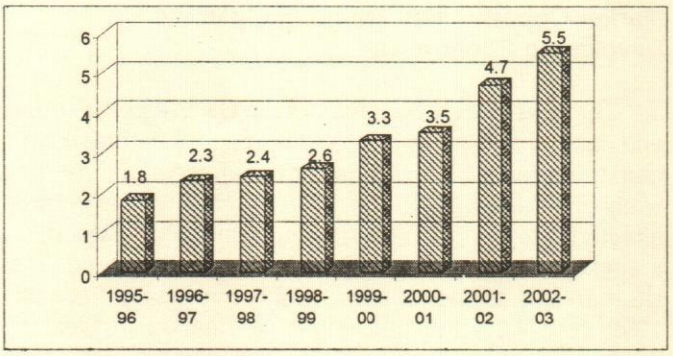

Exhibit 3: Growth of Component Industry in US $ Billion

Appendix

Passenger Car Industry: The Global & Indian Perspective

The Global Passenger car market is undergoing a transformation. In 2000, approximately 40 million cars were sold globally. The car markets of North America, Western Europe and Asia accounted for nearly 85% of global new car registrations in 2000. Between 1998 and 2000, new car registrations in these markets grew at a CAGR of only 6.9%, whereas during the same period, new car registrations in India grew by over 17%, the highest in any of the major passenger car markets.

Table 1: The Global Passenger Car Industry

(figures are in 000s)	1998	1999	2000	CAGR (%)
North America	8,183	10,017	10,453	13.0%
Western Europe	14,369	15,322	15,112	2..6%
Asia - ex Japan	3,062	3,711	4,111	15.9%
China	507	570	609	9.6%
India	**518**	**690**	**709**	**17.0%**
Japan	4,092	4,154	4,260	2.0%
Total (North America, Western Europe & Asia)	29,706	33,204	33,936	6.9%

(Source: CRIS INFAC Annual Review 2001)

Market Opportunities are primarily in the Developing Economies

The developed economies of the US, Western Europe and Japan have the highest levels of car penetration, and constitute over 70% of total new car registrations. Between 2000 and 2002, the sales of cars was adversely affected due to economic downturn in the US, which, as a single country, is the largest market in the world. The US market is expected to grow only marginally. Between 1999 and 2002, the passenger car market in Western Europe was stagnating. In 2002, sales volumes in Western Europe declined by approximately 2%. As a result of the recession in Japan, the second largest car market in the world, the demand for cars in Japan has been adversely affected. However, Japanese automobile companies, with global manufacturing capabilities, have not been significantly affected due to strong demand for their products in the overseas markets.

Trends in global passenger Car Industry

The automobile industry is capital intensive. Despite over 20 mergers and strategic investments and alliances in recent years, the global automobile industry faces over-capacity. This has led car manufacturers globally to increase the utilization of capacities and share a basic vehicle platform across several models in order to achieve economies of scale. The sharing of the basic vehicle platform spreads the development costs over a large volume base of various models. This increases the utilization of the platform, allowing car manufacturers to price new models at competitive prices. Typically, between 65% and 75% of the value of a vehicle comprises components that are outsourced. Hence, manufacturers make significant efforts to reduce the cost of procurement from component suppliers through strategies such as joint procurement of components with other car manufacturers, e-procurement and worldwide procurement. Car manufacturers have also sought to reduce costs by sharing manufacturing facilities with other car manufacturers, making improvements in technology and increasing their product portfolio and by focusing on initiatives such as built-to-order and mass customization. Manufacturers seek to enhance their customer base by providing related services and products such as automobile finance, pre-owned cars, fleet management and insurance.

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Implications of global trends for the Indian passenger car market

As a result of rising household income and decline in interest rates, along with current low passenger car ownership density, many global manufacturers have entered the Indian market. According to the Central Statistical Organisation, India had a GDP growth rate of 6.1%, 4.4% and 5.6% in fiscal 2000, 2001 and 2002, respectively. India is generally believed to have a high GDP growth potential aided by low cost of production and availability of skilled manpower. The high rate of growth in the sales of passenger cars in India is driven primarily by growth in the sales of passenger cars priced below Rs. 500,000, which constituted over 84% of total sales volumes in fiscal 2003.

The Indian passenger car industry

The passenger car industry in India grew at a nominal CAGR of approximately 3.6% during the 1960s

and the 1970s. Sales of passenger cars were limited by supply. There were only two manufacturers in the market, Hindustan Motors and Premier Automobiles, and they had limited production capacities. The import of passenger cars was restricted to the State Trading Corporation (STC) and foreign diplomats. There were quantitative restrictions on imports. The rate of customs duty levied on cars was 225%.

In 1982, the GoI entered into a collaboration with Suzuki and established Maruti, which commenced operations in fiscal 1984. Maruti launched a small car, the Maruti 800, which had an engine capacity of 796 cc, high fuel efficiency, contemporary design and was priced competitively. Maruti introduced the Omni in 1984, the Maruti 1000 in 1990, the Zen in 1993 and the Esteem in 1994. Each of these models provided customers with choices that were not available in the market. The entry of Maruti expanded the overall demand for passenger cars in India, leading to the industry growing at a CAGR of approximately 25% between fiscal 1984 and fiscal 1990. During 1986 to 1997, Maruti was the principal car manufacturer in India. During this period, Maruti encouraged the development of the automobile component industry and emphasized localisation of components and other input materials through collaborative efforts with vendors for the development of automobile components. In the 1980s, rates of import duties varied from 150% to 200%, based on the engine capacity of a car. In order to facilitate development of the car industry, the GoI has substantially lowered the rates of import duties levied on cars and components.

Significant events in the 1990s

In 1992, Suzuki's shareholding in Maruti increased to 50%. A year later in 1993, the GoI delicensed the passenger car industry in India. Overseas entities were permitted to set up automobile manufacturing facilities in India through joint ventures with Indian entities. The overseas entities were permitted to own up to 51% of the equity of such joint ventures until 1995, and more than 51% after 1995. As a result, overseas manufacturers such as General Motors, Ford, Daimler-Chrysler, Peugeot, Fiat and Daewoo Motors entered the passenger car and utility vehicles market in India. Most of the new car manufacturers introduced cars in the mid or large car segments. Premier Automobiles Limited and Maruti were the only manufacturers in the entry-level small car segment during this period.

Between fiscal 1993 and fiscal 1997, demand for passenger cars increased at a CAGR of 24%. Demand increased largely due to the availability of new models, high demand from the corporate sector, and increased availability of affordable consumer financing. Between 1997 and 1999, a number of new models were launched in the compact and mid-sized car segments.

Table 2: Indian Passenger Car Market

	1999-00	2000-01	2001-02	2002-03
Segment A:	**271,570**	**210,797**	**206,350**	**193,302**
Maruti	271,488	210,797	206,350	193,302
PAL	82	–	–	–
MUL market share in Segment A	100%	100%	100%	100%
Segment A share in overall market	44%	37%	36%	32%
Segment B:	**280,621**	**282,031**	**293,131**	**312,642**
Maruti	87,905	104,041	118,021	120,603
Fiat	16,178	7,205	20,379	23,317
Hyundai	69,449	64,877	67,909	82,892
Telco	54,499	43,797	64,037	72,713
Others	52,590	62,111	22,785	13,117
MUL market share in Segment B	31.3%	36.9%	40.3%	38.6%
Segment B share in overall market	45.7%	49.3%	50.8%	52.2%
Segment C:	**61,281**	**78,884**	**72,610**	**81,257**
Maruti	18,442	14,897	14,255	12,982
Fiat	4,567	2,149	898	2,615
Ford	7,988	18,024	14,650	14,954
GM	2,817	8,255	8,518	8,100
HM	8,545	7,783	6,589	5,105
Honda	9,698	10,009	9,600	12,000
Hyundai	6,215	16,083	17,700	19,152
Others	3,009	1,684	400	6,349
MUL market share in Segment C	30.1%	18.9%	19.6%	16.0%
Segment C share in overall market	10.0%	13.8%	12.6%	13.6%
Segments D&E:	**521**	**711**	**5,411**	**11,738**
Total	**613,993**	**572,423**	**577,502**	**598,939**

Source: Sales volumes data in the CRIS INFAC Annual Review 2002 and the CRIS INFAC Cars and Utility Vehicles Review and Outlook, dated May 2003, reclassified in accordance with price-based segmentation

Fiat - Fiat India Automobiles Pvt. Ltd.; Ford - Ford India Ltd.; GM - General Motors India Ltd.; HM - Hindustan Motors; Hyundai - Hyundai Motors India Ltd.; Honda - Honda SIEL Cars India Ltd.; Maruti - Maruti Udyog Ltd.; PAL Premier Automobile Ltd.; Telco - Tata Engineering and Locomotive Company.

In fiscal 2000, the Indian passenger car market grew sharply by 59.7% over the previous year primarily due to the entry of new car manufacturers such as Hyundai and Telco and introduction of new models such as the Matiz, the Indica and the Accent and advance purchases in anticipation of increase in sales tax rates. In the same year PAL discontinued its entry level small car model with the result that Maruti became the sole manufacturer of small cars priced below Rs. 300,000. In fiscal 2001, there was a correction in demand with a negative growth rate of 6.8%. In fiscal 2002 and 2003, the passenger car market in India grew only moderately.

Segment Volumes and Market share

The sales volumes of different passenger car companies in various segments in the Indian passenger car market for the last four years is shown in Table 2.

As may be seen from the above, the A and B segments have consistently constituted over 84% of the total passenger cars sold in the Indian passenger car market. In fiscal 2003, we had a 100% market share in the A segment and a 38.6% market share in the B segment resulting in 62% overall market share in these two segments.

Overall Market share

The overall market share of the various manufacturers in the Indian car market is shown in Table 3.

Table 3: Market Share of various Manufacturers

	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Maruti	83.1%	78.8%	61.5%	57.6%	58.6%	54.6%
Hyundai	0.0%	4.6%	12.3%	14.1%	15.2%	17.3%
Telco	0.0%	0.0%	8.9%	7.7%	11.1%	13.2%
Others	16.9%	16.6%	17.3%	20.6%	15.1%	14.9%

(Based on CRIS INFAC Annual Review 2002 and CRIS INFAC Cars and Utility Vehicles Review and Outlook, dated May 2003)Hyundai - Hyundai Motors India Ltd; Telco - Tata Engineering and Locomotive Company Ltd.

Manufacturing capacities and utilisation

The total installed capacity, which is measured at the time of installation of a plant as the number of vehicles a plant is expected to produce annually, is around 1,237,000 units in India. Maruti, which is the largest manufacturer in India, has generally operated at more than 100% capacity utilization. The capacity utilization is the ratio of the vehicles actually produced in a year and the installed capacity. In fiscal 2002, Maruti operated at a capacity utilization of 102%, as compared to the industry average of 57.8%.

The historical production volumes and capacity utilisation levels of various car manufacturers in India in fiscal 2002 is shown in Table 4.

Table 4: Production volumes and capacity utilisation of Car Manufacturers

(units)	1999-00	2000-01	2001-02	Installed Capacity (2001-02)	Capacity Utilisation (%) (2001-02)
Maruti	3,98,669	3,42,248	3,51,949	350,000	100.0%
TELCO	56,802	45,688	64,712	160,000	57.6%*
Hyundai	75,709	81,740	93,670	120,000	78.1%
Daewoo	n.a.	n.a.	n.a.	110,000	n.a.
Ford	n.a	n.a	10,287	100,000	10.3%
Hindustan Motors	26,673	25,774	19,398	64,000*	36.2%*
Fiat	16,039	n.a	n.a	50,000	n.a.
Honda	n.a.	2,652	10,310	30,000	34.4%
GM	3,108	8,324	8,135	25,000	32.5%
Daimler Chrysler	436	880	1,415	10,000	14.2%
PAL-Peugeot	32	–	–	n.a.	n.a.
PAL	54	–	n.a.	n.a.	
Total	5,77,522	5,07,306	5,59,876		

Source: CRIS INFAC Annual Review 2002. n.a: Not Available* includes cars and utility vehicles

1. Sales Figures for Daewoo Motors India Ltd. (estimated) and Fiat India Ltd. have been taken as a proxy for production, as the production numbers for these companies are not available.
2. Production figures include the exports of vehicles. Between fiscal 2002 and fiscal 2007, the entire Indian passenger car market is expected to grow by approximately 9.5%, largely as a result of increasing demand for segment B cars.

Sector Outlook

Segment A

This is the entry-level and the most price sensitive segment constituting 32.3% of the total Indian passenger car market in fiscal 2003. Maruti is the sole manufacturer in this segment since fiscal 2000. In fiscal 2003, this segment accounted for sales volumes of 193,302 cars. Due to the low per capita income levels in India, the price of ownership of cars significantly affects the demand for cars. Between fiscal 2002 and fiscal 2007, this segment is expected to post a CAGR of 2.7%.

Segment B

In fiscal 2003, this segment constituted 52.2% of the total Indian passenger car market and is expected to grow to 57.6% of the Indian passenger car market by fiscal 2007 at a CAGR of about 12.3%. In fiscal 2003, there were eight models in this segment. Due to the present low per capita income in India, the price and cost of ownership of cars are significant factors that affect demand for cars in this segment.

Segment C, D, and E

In fiscal 2003, segment C, D and E constituted about 15.6% of the total Indian passenger car market. There are 11 manufacturers with 24 models in these segments. These segments typically have low sales volumes. Therefore, high growth rates of 11%, 19% and 35%, respectively, are expected between fiscal 2002 and fiscal 2007. New model launches, growth in per capita income levels, high aspirations and status associated with larger cars, are the key factors affecting demand for cars in these segments.

Factors affecting Demand for Indian Passenger Cars

Demand for cars depends on a number of factors. The key factors affecting demand for passenger cars in India are per capita income, introduction of new models, prices of cars, availability and cost of consumer financing, incidence of duties and taxes, fuel costs and the quality of road infrastructure.

Due to low per capita income in India, the price and cost of ownership of cars is a significant factor in demand for cars. According to the Statistical Outline of India 2002-03 by Tata Services Ltd, the per capita gross national product per capita which is an indicator of per capita income levels, has increased to Rs.20,320 in fiscal 2001 from Rs.14,325 in fiscal 1997, a CAGR of 9.13%. According to the National Readership Survey 2002, the proportion of individuals with annual per capita income exceeding Rs. 48,000 has increased from 14.2% in 1990 to 20.4% in 2002.

The fiscal policies of the government affect the prices of cars sold in India. The excise duty rate of 24%, the central sales tax rate of 3%, the local sales tax rates and other municipal, road taxes and registration taxes constitute approximately 45% of the ex-showroom price of a car. In March 2001, excise duty rates for passenger cars in India were reduced from 40% to 32%. In February 2003, the GoI reduced the rates further to 24% and also reduced rates of customs duty levied on imported components from 30% to 25%.

Recently, there has been progress in major highway and road construction projects, such as the Golden Quadrilateral Project, a highway connecting the four metropolitan areas of Kolkata, New Delhi, Mumbai and Chennai. Availability of better road infrastructure will also affect demand for cars.

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Focus

Best Practices in the Automobile Industry

A.M. Kannan

A number of well-known international auto manufacturing companies have set up manufacturing units in India. The aim of this article is to compare the performance of the international companies, especially the Japanese companies, with pure Indian companies, and to assess whether there are any reasons to believe that the best international practices are being practised in the Indian auto industry. The focus of the article is on Inventories and supply chain, as well as on manufacturing practices.

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Inventory and Supply Chain Practices

Supplier partnership and management of strategic partnership are important for a well managed supply chain. Success of the partnership, and hence the supply chain, is dependent on both external collaboration (between the supplier and the company) and internal collaboration (within the company). The key features of external collaboration are goal congruence, and the level of trust between the manufacturer and the strategic supplier partner. The elements of internal collaboration are top management support and cross-functional teamwork. They have also concluded that companies that invest time and resources in lasting partnerships with the supplier partners can generate lasting competitive advantage for their respective organisations.

The Japanese manufacturer-supplier relationship is typically in the form of a Keiretsu, wherein there is a fairly well established cross holding between the manufacturer and suppliers. Jeffrey H Dyer (HBR July-Aug 1996) reviews the benefits that accrued to Chrysler Corporation when it shifted from an arms length supplier - manufacturer relationship to a supplier partnership. Chrysler was able to reduce the number of suppliers from about 2500 to about 1150 and entered into long term contracts unlike the earlier practice of 2 year contracts. As a result, Chrysler achieved up to 40% savings in vehicle development costs, savings in ordering costs and an overall increase in per car profitability from around $250 to an American industry record of $ 2110. Unlike the Japanese Keiretsu, Chrysler has not had any cross holdings with its suppliers. To that extent, the model is not culture specific and can be duplicated.

Jeffrey H Dyer (HBR Nov-Dec 1994) has studied the Japanese practice of suppliers having dedicated assets for parts supplied to auto manufacturers. Dedicated assets have resulted in supplier plants being located near the main manufacturer's plant. Frequent part deliveries, and a close interaction between the technical personnel of both the supplier and the manufacturer are, therefore, possible. The average distance between the supplier

and the auto manufacturer in Japan is about 87 miles, whereas it is 427 miles in the US. The average number of deliveries per week is 40 in Japan, as against seven in the US. The result is a significantly lower level of inventories for both the supplier and the auto manufacturer in Japan as compared to the US.

Jeffrey K. Liker, et al (2000) have compared the performance of US suppliers to Japanese auto makers in the US and US suppliers to US auto makers in the US. They have concluded that the performance of suppliers to Japanese automakers is significantly superior to the suppliers to US auto makers. They have also noted that where a supplier makes supplies to both US and Japanese manufacturers the performance of the supplier is significantly better when supplying to the Japanese manufacturer. Some of the reasons that they attribute to account for the difference are:

- Japanese manufacturers work with suppliers to develop lean capabilities
- Japanese manufacturers resort to level production scheduling to avoid demand spikes
- They create a disciplined system of delivery time windows
- They develop a lean transportation system to handle mixed load and small lot deliveries
- They encourage the supplier to deliver what the assembly plant requires, even if it means partially filled trucks
- They compensate for long distances by resorting to milk runs or compounded deliveries. This enables them to receive small lot sizes, and also to minimise transportation costs.

Manufacturing Practices

The essence of the best practices in manufacturing is a continued shift towards a lean production system that enables a manufacturer to respond to market requirements quickly with quality products. The basic tenets of lean manufacturing were spelled out clearly as a result of the IMVP study in the (Jim Womack, et. al Machine that Changed the World - Harper Collins Publishers). The gist of lean manufacturing tenets are listed below:

- Establishing a continuous flow of operations in the production process
- Minimising WIP through small batch production that is, in turn, facilitated by short set up times
- Establishing a pull system of production planning that is, in turn, highly responsive to customer demands
- Relentlessly driving towards continuous improvement in all areas of manufacturing by the active involvement of all employees

To quote the authors, a truly lean plant has two main organisational features "It transfers the maximum number of tasks and responsibilities to those workers actually adding value to the car on the line, and it has in place a system for detecting defects that quickly traces every problem once discovered to its ultimate cause."

The findings of the study were:

- The Japanese companies, the originators of the lean production systems, consistently outperformed their US and European counterparts in all key performance indices, asset utilisation, manpower productivity, inventory turn, product development time and quality parameters such as defects per 100 vehicles.
- Japanese companies also tended to take with them their practices when they established plants overseas. Though the performances of these plants were not on par with the parent Japanese plant, they were, nevertheless superior to the local plants of the country where the plants were set up.

John F Krafcik (1988) in his article Triumph of the Lean Production System has concluded that:

- Lean plants are more capable of simultaneously achieving high levels of productivity, quality, and product mix complexity.
- Production management policy has a tremendous impact on plant operating performance. American plants with lean policies have been able to achieve very high performance levels, comparable to the Japanese ones.

The impacts of these findings are clear. A conscious effort to go towards a lean manufacturing production system seems to be a necessity for long-term value creation in companies.

The Indian Scenario

The Indian automobile industry has been, since independence, a much-protected one, and the number of players has been limited. Competition, therefore, has

not been a way of life with the industry for a number of years. There has been a sea change, however, in the scenario since the process of liberalisation began. The number of players has gone up significantly, and apart from major Indian industrial houses, some of the leading foreign manufacturers have also set up manufacturing units in India. The Indian auto industry has, therefore, progressed from a protected market to a reasonably competitive market in the last 10 to 12 years.

Among the foreign players, Japanese companies, too, have established manufacturing companies in India. The Japanese have been known to establish their lean practices in all the countries where they establish manufacturing units.

Published company reports are the main source of information, and the performance of Indian, Japanese and American companies in India over the period 1997 to 2002, with reference to key performance indices have been used as evidence. In analysing data, companies that have joint venture operations (as against only technical collaborations) with Japanese companies have also been treated as Japanese companies. During the period, some companies such as TVS Motors have become purely Indian owned, but since they have had Japanese influences (as part of the joint venture with Suzuki) they have been treated, for the study, as a Japanese company.

Best practices in supply chain ultimately lead to reduced level of inventories, and therefore, the inventory turnover ratios of Indian and Japanese companies have been compared over the last five years. Comparisons have also been made separately for four wheelers as well as two and three wheelers. The data of the respective inventory turnover is displayed in Figs. 1 and 2.

Fig. 1. Inventory Turnover: Two and Three Wheeler Industry

In both the two-three wheeler and passenger car industries, the Japanese manufacturers or even those who have had joint ventures with the Japanese have been able to perform better than pure Indian companies. In addition, in terms of inventory usage, the Japanese companies in the two wheeler industry seem to be doing much better than the Indian companies, as the Indian company index is relatively stagnant while the Japanese one has shown an increasing trend.

Fig. 2. Inventory Turnover: Passenger Car Industry

Best practices in manufacturing are expected to result in improved profitability and improved usage of assets (reflected in the asset turnover ratio). The figures of asset turn over ratios of Indian and Japanese companies are shown in Figs. 3 and 4.

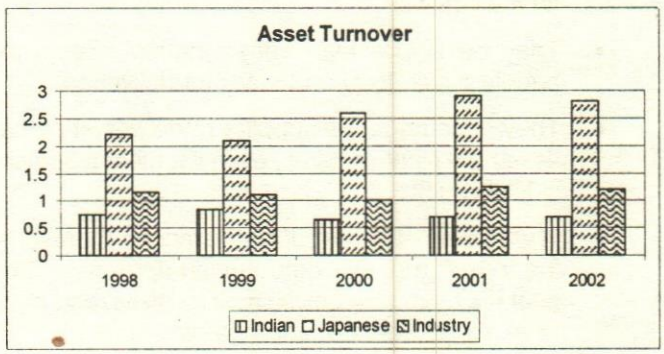


Fig. 3. Asset Turnover Two and Three Wheeler Industry

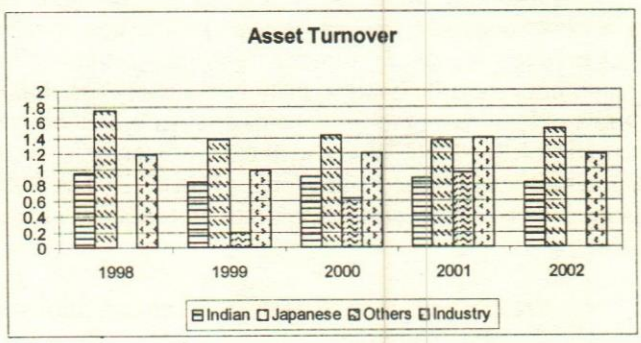


Fig. 4. Asset Turnover - Passenger Car Industry

The trends in asset turnover also mirror the trends in the inventory turnover figures. The category "Others"

in the passenger car industry represents the emergence of the Korean company Hyundai, which has made significant strides in the last few years. It may be noted that while the company has already become one of the best in terms of inventory turns, the asset turns are already on par with the Indian Industry.

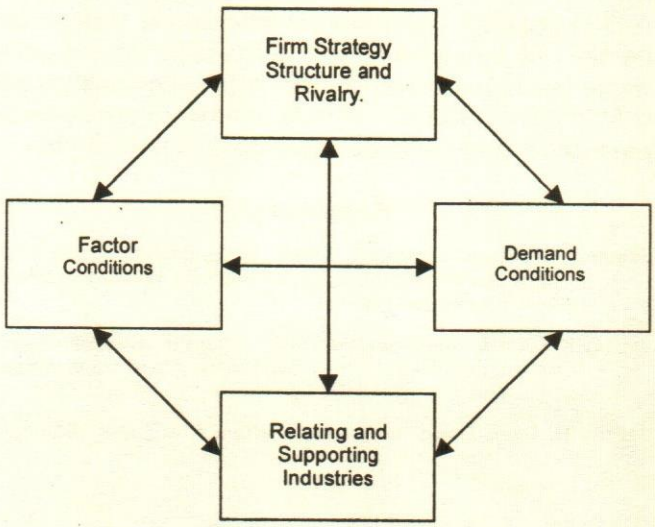
It is evident from the data available that, on an average, Indian companies do not perform at the level that the Japanese companies do. The data also seems to suggest that the Japanese have tried to implement their lean practices in India, as has been their practice when they establish manufacturing units in other countries. The data also suggests that the performance indices of Indian manufacturers have remained relatively stagnant over the five year period, while the Japanese companies and Korean companies have shown a steady improvement in performance over the last five years. One clear conclusion is that the competitive market environment will push all the manufacturers towards sustained improvements to remain competitive. The corollary to this is that Indian manufacturers have to make significant strides to become more competitive.

There is ample evidence to suggest that the entry of foreign manufactures has indeed brought in some of the best practices into the Indian auto industry. The practices themselves are well documented and need to be adopted by all manufacturers if they are to remain competitive in the long run. The study has looked at the auto industry at the macro level or at the industry level rather than concentrating on any one practice and assessing the impact of that practice or the prevalence of that practice in the Indian auto industry. To that extent, the study has its limitations. Nevertheless, the study does help in ascertaining whether the international manufacturers, especially the Japanese, who have set up units in India, have bought with them the operational practices that have made them the best in the industry.

The Future Scenario

Michael Porter in his article "The Competitive Advantage of Nations" (HBR March-April 1990) has argued that a nation's competitive advantage is dependent on four factors:

1. Factor conditions: The nation's position in factors of production, such as skilled labour or infrastructure.
2. Demand conditions: The nature of market demand for the industry's product or service.
3. Related and supporting industries: The presence or absence in the nation of supplier industries and other related industries that are internationally competitive.
4. Firm strategy, structure and rivalry: The conditions in the nation governing how companies are created, organised and managed, as well as the nature of domestic rivalry.



Determinants of National Competitive Advantage

Looking at the Indian auto industry with reference to the above model, some of the conditions are indeed favourable. This is true especially with respect to the level of domestic competition. Porter also mentions the emergence of industry clusters. As far as the auto industry in India is concerned, three clusters, one each in Pune in the west, Gurgaon in the north, and Chennai in the south are well on their way to being formed.

Cluster formation could help in reducing the distance from the auto manufacturer to the parts supplier. Deliveries could be in small batches, and concepts like milk runs could be more efficiently managed. Cluster formation could also result in greater interaction between the auto manufacturer and the parts supplier. This will lead to the formation of a partnership relationship between suppliers and customers as against the current prevalent arms length relationship. Formation of lean value chain in each of the clusters, lead by the major manufacturing units in each cluster, is therefore a likely outcome in the near future. Cluster formation is also expected to help in the formation of a competent and competitive component industry. At the moment, the component industry is far too fragmented, and only a few are able to enjoy the benefits of economies of scale.

Conclusion

The Indian economy is slated to grow at a faster

pace in the coming years. This will result in increased demand for all goods and services, automobiles included. A period of sustained growth of the auto industry can, therefore, be expected. International firms presently in India will try to consolidate their position in the increasingly competitive environment. Tried and tested best practices are one way to improve their competitive position. The advent of international majors can be seen as a definite benefit to the auto industry as a whole. As for the Indian companies, the competition will only increase, and it is in their interest to adopt these practices if they are to be competitive in the long run.

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Teamwork is a make or break situation. Either you help make it or the lack of it will break you.

– Kris A. Hiatt

Application of Smart Materials in Automobiles

V. Sampath

The modern automobile is made up of a number of components. Different materials as well as processes are used to produce them. Over the years, a number of new and advanced materials have replaced conventional automotive materials. This has resulted in enhancing the lightness, fuel efficiency, safety and passenger comfort of the cars manufactured. The quest for new materials and processes still goes on with a view to enhancing the overall performance of the automobile and increasing the safety and comfort of the passengers. In recent times, smart materials, such as shape memory alloys, piezoelectric materials, electrorheological fluids, and magnetostrictive materials have been used extensively in automotive applications. In this paper, the principles, applications, advantages and limitations of smart materials in general, and shape memory alloys in particular, are highlighted. Of late, there has been a lot of emphasis on increasing the safety aspect of cars. The concept of smart cars has been gaining momentum. This aspect is also highlighted in this paper.

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Smart Materials

Smart materials are those materials that possess both intrinsic and extrinsic capabilities to respond to stimuli and environmental changes. They respond to changes in temperature, moisture, pH, magnetic field, electric field, etc. The term "smart materials" encompasses a wide variety (Harvey, 2002) of materials, such as shape memory alloys, piezoelectric materials, smart gels, electrostrictive materials, magnetostrictive materials, rheological fluids, electrochromic materials, pH-sensitive materials, etc. Depending upon whether these materials respond with a change in shape and/or length or a change in a key material property, smart materials can be used as actuators and/or sensors.

Suitability and Advantages

The smart materials that find applications in modern cars offer many advantages and newer capabilities over conventional materials. The following are some of the advantages that they have to offer:

1. High integrity and reliability
2. Low power consumption
3. Absence of moving parts
4. Synergistic capabilities
5. High suitability for MEMS applications

Many smart technologies are commercially exploited by the automotive industry. These smart technologies provide ample scope for innovation in the context of automotive applications.

Innumerable patents are being filed year after year all over the world in the area of smart materials /technologies. Piezoelectrics alone account for around 200 patents a year. Smart materials have a high market

potential for automobile applications. The breakup for smart materials for a total market output value of $1b is given below:

1. Shape memory alloys (SMAs) : 10%
2. Magnetostrictive materials : 5%
3. Magnetorheological fluids : 5%
4. Piezoelectric ceramics : 75%

Application of Smart Materials in Automobiles

The following are some of the specific applications of smart materials in automobiles:

SMAs

1. Open-close mechanisms
2. Release mechanisms
3. Active braking systems
4. Active skin systems

Piezoelectric Materials

1. Sensors for wiper actuation
2. Sensors for side impact diagnosis (in smart cars)
3. Sensors for force/motion
4. Sensors for platform stabilization
5. Ultrasonic motors
6. Sonar arrays for collision avoidance (in smart cars).

Magnetostrictive Materials

1. Active cabinet noise control
2. Sonar for collision avoidance (in smart cars)
3. Active sensing and actuation

Magnetorheological / Electrorheological Fluids

1. Active clutch mechanisms
2. Position and velocity control
3. Active suspension

MEMS

1. Suspension systems
2. Tyre pressure control
3. Air bag deployment
4. Fuel pump pressure
5. Engine coolant temperature and quality
6. Fuel injection control
7. Antibraking systems, etc.

Shape Memory Alloys

Shape memory alloys are monolithic smart materials that respond to changes in the environment and external stimuli. They usually respond to these changes/stimuli by recovering their predefined/original shape and size.

Shape memory alloys exhibit two distinct phenomena, namely shape memory effect and superelastic effect. Shape memory effect shows the material's response to temperature, i.e, thermal memory. But superelastic effect indicates the material's response to stress, i.e., mechanical memory. These are schematically illustrated in Figs. 1 and 2. The formation of twinned / self-accommodating martensite is responsible for these phenomena. These are diagrammatically illustrated in Figs. 3 and 4. Research work in the area of shape memory effect was initiated by a Swedish scientist, Arne Olander, in 1932 in Au-Cd (Mavroidis, Pfeiffer & Mosley, 1999). A

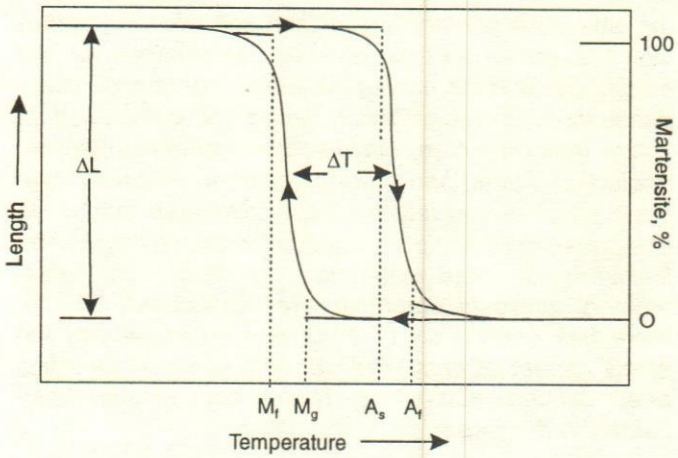

Fig. 1. Schematic diagram of shape memory effect

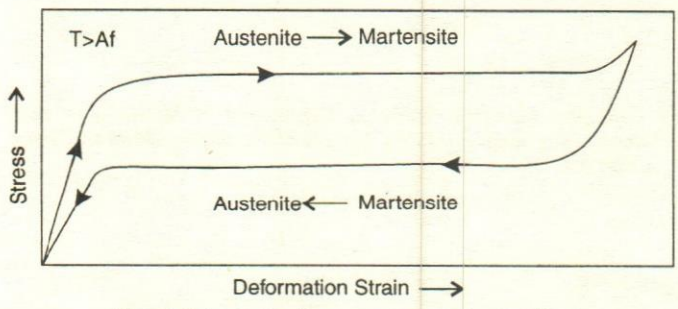

Fig. 2. Schematic diagram of superelastic effect

lot of developments have taken place in shape memory alloy research, especially in the past decade or so from the point of view of commercial applications of shape memory alloys. Table 1 traces the history and development of shape memory alloys. Shape memory alloys are used as smart materials for a wide variety of applications (Humbeeck, 1999). The applications of shape memory alloys can be broadly classified into six categories (Hogdson, 1990):

1. Free recovery applications (e.g., blood-clot filters).
2. Constrained recovery applications (e.g., hydraulic couplings).
3. Work output or force actuator applications (e.g., fire safety valves and circuit-board edge connectors). (Fig. 5).
4. Proportional control applications (e.g., fluid flow control valves).
5. Superelastic applications (e.g., eyeglass frames and guidewires for steering catheters into vessels in the body) (Fig. 6).
6. Damping applications (e.g., automobile bumpers and earthquake-resistant structures).

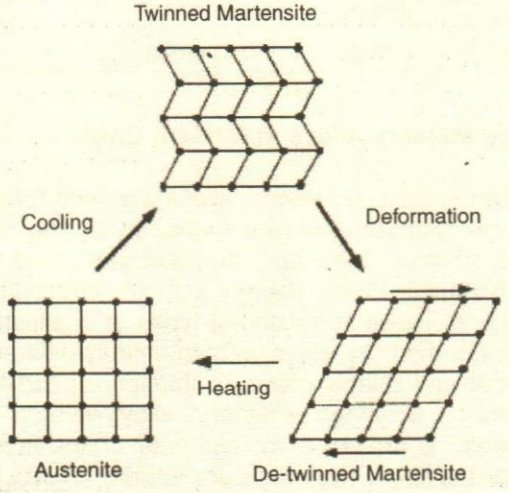

Fig. 3. Change in the crystal structure during shape memory effect

Table 1: History of Shape Memory of Alloys (Refs.5,6)

Year	Scientists	System	Phenomenon
1932	A. Olander	Au-Cd	Pseudoelastic behaviour
1938	Greninger and Mooradian	Cu-Zn	Formation and disappearance of martensite plates with decrease and increase in temperature
1949	Kurdjumov and Khandros	–	Thermoelastic behaviour of martensite
1951	Chang and Read	Av-Cd	Thermoelastic behaviour of martensite
1961	Buehler and Wiley	Ni-Ti	Shape memory effect
1968	Johnson and Alicandri	Ni-Ti	Implant applications
1980s	–	–	Orthodontic and orthopaedic applications
1990s	–	–	Stent applications (SE, SME)

Even though a large number of alloy systems exhibit shape memory effect, it is those alloys that show a large amount of strain recovery and those that generate a higher magnitude of stress that find extensive application in diverse fields. These are invariably based on Ni-Ti, Cu-Al-Ni and Cu-Zn-Al alloys. Table 2 lists the different alloy systems that exhibit shape memory effect. SMAs based on Ni-Ti, in particular, are used extensively for a number of applications, especially as actuators in automotive applications. The principles of operation of shape memory alloy actuators are schematically explained in Fig. 5 and Fig. 6. Some shape memory alloys recover their original shape only upon heating. These alloys exhibit one-way shape memory effect. But some alloys recover their predefined shape both upon heating and cooling. These exhibit two-way shape memory effect, i.e., they remember both their high and low temperature shapes. One-way and two-way shape

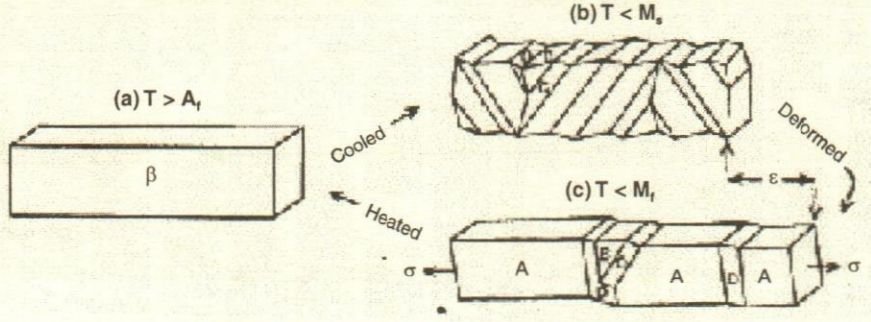

Fig. 4. Crystallography of shape memory effect

memory effects are schematically illustrated in Fig. 7 and Fig. 8.

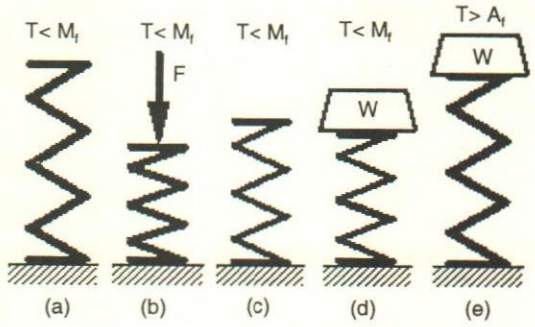

Fig. 5. Schematic diagram of principle of SMA actuators: a) Sample in martensitic condition; b) Deformation of sample at T < Mf (a-b); c) Unloading of sample (b-c); d) Reloading of sample with weight (c-d); e) Shape recovery against load on heating to T A_f (d-e) resulting in work. (Stalmans and Humbeeck, 1995)

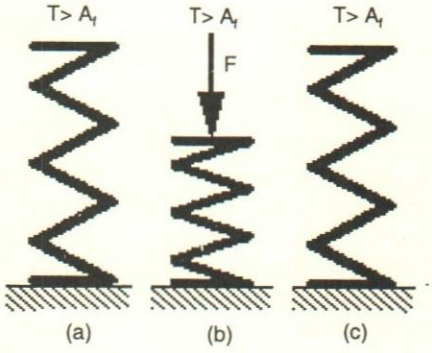

Fig. 6. Schematic diagram of super-elastic effect: a) Sample in austenitic condition; b) Deformation of sample in austenitic condition (T > A_f); c) Unloading of sample and recovery of shape (Stalmans and Humbeeck, 1995).

Shape Memory Alloys in the Indian Scenario

Shape memory alloys are used extensively in cars produced by the automobile manufacturers abroad. But shape memory alloys have not found even limited applications in the cars manufactured by Indian companies despite the enormous potentials shown by them. First of all, this is attributed to the lack of awareness of the potentialities of shape memory alloys. Secondly, there is a dearth of relevant and reliable data pertaining to the mechanical properties and shape memory characteristics of the presently available shape memory alloys for direct application by the automotive industry.

Table 2 : Composition of shape Memory Alloys

Alloy System	Composition (%)	Transformation Temperature (°C)	Transformation Hysteresis (°C)
Ag-Cd	44-49 Cd	-190–150	15
Au-Cd	46.5-50 Cd	30 to 100	15
Cu-A1-Ni	14-14.5 wt.%A1 3-4.5 wt.% Ni	-140 to 100	35
Cu-Sn	15 Sn	-120 to 30	–
Cu-Zn	38.5-41.5 wt.%Zn	-180 to -10	10
Cu-Zn-X (X = Si, Sn, A1)	A few wt.% of X	-180 to -10	10
In-Ti	18-23 Ti	60 to 100	4
Ni-A1	36-38 A1	-180 to -100	10
Ni-Ti	49.5 Ni	-50 to 110	30
Fe-Pt	25 Pt	-130	4
Mn-Cu	5-35 Cu	-250 to 180	25

Shape Memory Alloys in Modern Cars

Though shape memory alloys are used for a variety of applications in the cars produced by the manufacturers abroad, they are, in particular, used for two specific applications, namely actuator and bumper applications. These two different types of applications call for shape memory alloys with an entirely different set of material and shape memory characteristics. While for actuators, a shape memory alloy with a smaller hysteresis is preferred, for bumpers, shape memory alloys with a larger hysteresis are desired. Shape memory alloys with a large recovery force and a large recovery strain are desired for actuator applications. In present

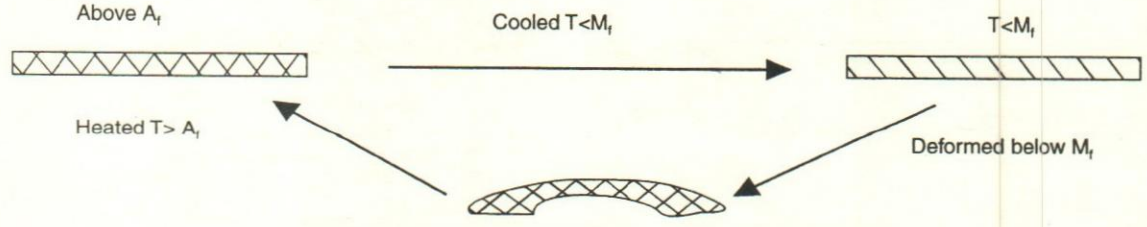

Fig. 7. Schematic diagram of one-way shape memory effect

day cars, different types of sensors are used to meet different requirements, ranging from improving engine performance to passenger comfort to safety. Though they are not glaringly visible to the onlooker, their contribution to the vehicle's performance is phenomenal.

Table 3 : Properties of NiTi Shape memory Alloy

Melting Point	1300°
Density	6.45 g/Cm^3
Resistivity	
Martensite Austenite	18W/cm°C 8.5W/cm°C
Corrosion Resistance	Similar to 300 series stainless steel or titanium alloys
Young's Modulus	
Austenite Martensite	83GPa 28–41 GPa
Yield Strength	
Austenite Martensite	195–690 GPa 70–140 GPa
Ultimate Tensile Strength	895 GPa
Transformation Temperature	-200 to 110°C
Latent Heat of Transformation	167 KJ/Kg.atom
Shape Memory Strain	8.5% (max.)

In this paper, the use of shape memory alloys for actuator and bumper applications in automobiles is discussed in detail. The use of other smart materials for automotive applications is also highlighted.

A number of factors influence the mechanical properties and shape memory characteristics of the alloys used in automotive applications. Chemical composition, heat treatment, mechanical working and grain size are some of the most important factors that influence the transformation temperatures of shape memory alloys. Even though shape memory alloys are used for actuator applications in cars, different parts require actuators/alloys that respond to different ranges of temperature (Stoeckel, 1990). It is the transformation temperatures, namely Ms, M_f, As and A_f that help decide the specific applications for which the shape memory alloys are to be used. For actuators, the smaller the hysteresis width, the better the actuation capabilities are. The response time should be as small as possible. In fact, one of the drawbacks that the users of shape memory alloys have to contend with, especially when they are used for actuation, is their slow response. But these days scientists have devised methods by which this can be overcome. By controlling the actuator shape/size and design, they have successfully been able to overcome this problem. There is another approach that is used for overcoming this problem - that of using forced air as an external coolant.

Cars produced in developed countries, are equipped with smart technology.

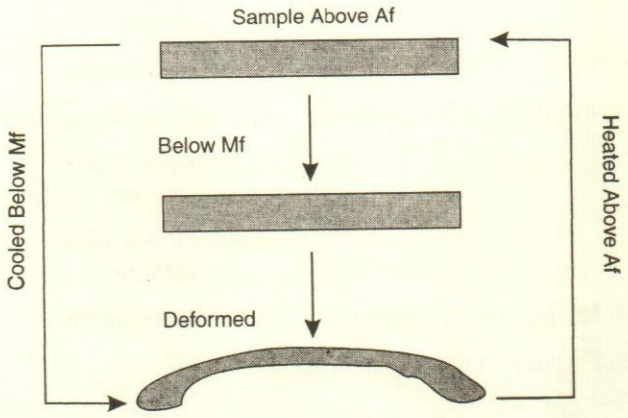

Fig. 8. Schematic diagram of two-way shape memory effect

Suitability of Shape Memory Alloys for Actuators

SMAs, in general, are highly suitable for actuator applications because they fulfill the property requirements of actuator applications (Huang, 2002). Recently, SMAs have been attracting keen interest as smart materials, since they can function as sensors and actuators simultaneously (Otsuka & Kakeshita, 2002). In brief, the following are the most important properties required of SMAs for actuators (Stoeckel, 1990):

1. Simplicity, compactness and safety. The SMA actuators are simpler in design, safer to use and smaller in size compared to the conventional actuators.
2. Capability to work without producing noise, dust and spark.
3. Capability to work in zero-gravity working conditions.
4. High power-to-weight ratio.
5. Excellent corrosion resistance.
6. High bio-compatibility.

SMA Actuators in Automobiles

The following are the automotive parts where SMAs are used:

1. Control mechanisms:
   a) Transmission control
   b) Engine control
   c) Climate control
   d) Wiper pressure control
2. Locking mechanisms:
   a) Engine hood lock
   b) Filter inlet lock
   c) Trunk lock
   d) Central locking
3. Adjustment mechanisms:
   a) Seat-belt adjustment
   b) Rear-view mirror adjustment
   c) Shock absorber adjustment
4. Management systems: Fuel management
5. Foglamp cover / slats / louvers

The above list is by no means exhaustive, but has only been given to illustrate the wide range of possibilities that exist for the application of shape memory alloys in automobiles. This serves as an impetus for exploring new applications for shape memory alloys in automobiles.

As has already been mentioned, though a number of alloys exhibit shape memory effect, it is those that are based on Ni-Ti, Cu-Zn-Al and Cu-Al-Ni that have found wide acceptance and commercial applications. The specific choice of the actuator material is influenced by the temperature range in which it is used. In recent times, attempts have been made to increase the shape memory and actuation capabilities of these alloys by modifying the composition using ternary and quaternary alloys based on Ni and Cu. These days there are also attempts to use shape memory alloys based on Fe-Mn-Si and Ni-Al as well. These are suited for high temperature actuator applications.

Though Ni-Ti, Cu-Zn-Al and Cu-Al-Ni have been suggested as suitable candidate materials for actuators in cars, they have not been used to the same extent. This is because using SMAs with different compositions that respond at different temperatures is not a viable proposition. Secondly, in automobiles, different parts require different temperature ranges for actuation. In all, the actuators have to operate over a range of temperatures, typically from -10°C (in winter in certain parts of India) to 150°C (in the bonnet/hood region).

Table 4: Properties of Copper-Based Shape Memory Alloys

Properties	Cu-Zn-Al	Cu-Al-Ni
Thermal Properties		
Melting Temperature (°C)	950 – 1020	1000 – 1050
Density (g/cm^3)	7.64	7.12
Resistivity (%Ω)	8.5 -9.7	11 – 13
Thermal Conductivity (W/m°C)	120	30 – 43
Heat Capacity (J/Kg°C)	400	373 – 574
Mechanical Properties		
Young's Modulus (GPa)		
Beta Phase	72	85
Martensite	70	80
Yield strength (MPa)		
Beta Phase	350	400
Martensite	80	130
Ultimate Tensile Strength (MPa)	600	500 – 800
Shape Memory Properties		
Trans. Temp (°C)	< 120	< 200
Recoverable Strain (%)	4%	4%
Hysteresis (ΔT)	°C)	15 – 25

With a view to overcoming some of the problems posed by the commercially available SMAs, scientists and engineers are working all over the world to develop new shape memory alloys. These alloys respond to high temperatures (HTSMAs), Humbeeck, 1999). The addition of Zr, Hf and Pd to Ni-Ti is now being tried. Even SMAs based on Fe are being explored. But Fe-based SMAs show only one-way shape memory effect. The major goal of present day researchers is to enhance the temperature range of actuation of the SMAs to 150-200°C.

The following are, in general, some of the important automotive parts where shape memory alloys are used:

1. In manual transmission gears to reduce the noise level.
2. In fog lamp cover to automatically close/open it.
3. In outer vent control valve.
4. In motor cycle drain system to prevent the coolant from freezing.

SMAs are used in outer vent control systems to avoid the evaporation of fuel in automobiles, and also in devices to open parallel hydraulic channels in automatic transmissions. They find application in air-conditioners

to change the direction of air flow depending upon the temperature of the air.

In Japan, high speed trains make use of shape memory alloys to control the automatic oil valve in the gear box. The oil valve is controlled by an SMA spring that opens and closes it. The main purpose of the valve is to lubricate the pinion gears using high or low volumes of oil flow depending on the oil temperature. This arrangement helps maintain the oil temperature so that the train has a smooth and stable run.

Shape memory alloys are still to be used to their full potential in automotive applications in a country like India.

Suitability of Nitinol for Actuators

Among a host of shape memory alloys, it is those that are based on Ni-Ti that are especially found highly suitable for actuator applications for the following reasons:

1. High electrical resistivity
2. High power-to-weight ratio
3. Large recovery strain
4. Large recovery stress
5. High corrosion resistance
6. High biocompatibility

The properties of Ni-Ti and Cu-based shape memory alloys are given in Tables 3 and 4.

Types of Actuators

There are two different classes of actuators that are used in automotive applications: thermal actuators and electrical actuators. Whether it is thermal actuators or electrical actuators that are to be used and the exact location in the car where they are to be used are dictated by the service conditions. An appropriate choice is then made. Thermal actuators play a dual role. They act both as sensors and actuators. They are a little different from electrical actuators in the sense that they sense the change in the temperature of the environment/part and actuate the appropriate mechanism. They regain their original shape or generate stresses while undergoing a change in temperature. On the other hand, electrical actuators actuate/move a part or object. To perform this they are to be energized. Electrical actuators are, therefore, first heated by passing an electric current through them. The material is heated above its A_f temperature by passing an electric current through it. It regains its original/undeformed shape in the austenitic condition. In trying to recover its original shape, it does some work against a load/stress.

Problems with Shape Memory Alloys for Actuators

Even though Ni-Ti, Cu-Al-Ni and Cu-Zn-Al shape memory alloys are used in actuator applications, problems are associated with their production and processing. The difficulties associated with the production and processing of these alloys are given below:

Ni-Ti Alloys

1. Melting and solidification are to be done in a vacuum. This necessitates the use of high vacuum furnaces
2. High hardness
3. High brittleness
4. Difficulty in machining, rolling, forging and welding
5. High cost of production
6. Low transformation temperatures (100 °C).

Cu-Ni-Al Alloys

1. Large grain-size.
2. Large elastic anisotropy.
3. Segregation of impurities at grain boundaries.
4. High brittleness.
5. Slightly lower transformation temperatures (~200°C) even though higher than those of Ni-Ti and Cu-Zn-Al alloys.

Cu-Zn-Al Alloys

1. Coarse grain size
2. Low strain recovery
3. Low transformation temperatures
4. Instability of structure at low temperatures
5. Biological incompatibility
6. Poor corrosion resistance
7. Degradation of properties due to aging at low temperatures.

Ni-Al Alloys

1. Upon heating martensite transforms to Ni_5Al_3.
2. Poor ductility due to formation of brittle phases.

In summary, the following are the problems associated with the presently available/used low temperature shape memory alloys (Humbeeck, 1997).

1. Low transformation temperatures
2. Stabilization of martensite
3. Decomposition of martensite or decomposition of austenite (parent phase)
4. Brittleness due to high elastic anisotropy
5. Brittleness due to brittle phases or precipitates
6. Coarse grain size

Methods of Production of Shape Memory Alloys

Different techniques, such as sputter deposition, combustion synthesis and and mechanical alloying are used to overcome these difficulties by yielding SMAs with finer grains.

With a view to increasing or decreasing the transformation temperatures of the alloys based on Cu-Al-Ni, Cu-Zn-Al, Ni-Ti and Ni-Al, quaternary and ternary additions are made to the alloys. These quaternary and ternary additions, apart from increasing / decreasing the transformation temperatures of the shape memory alloys, increase their ductility and machinability. For example, the addition of Mn increases the ductility and machinability of Cu-Al-Ni alloys. Grain refinement (Sure and Brown, 1984; Elst et al, 1986; 1988) using Ti, B and Zr also increases their ductility.

Fatigue properties of Ni–Ti and Ni-Ti-Cu Alloys

For the binary Ni – Ti alloy with the monoclinic structure, even though the recoverable strain is the highest, its fatigue properties are not as good. But R–phase has excellent fatigue properties even though the recovery strain is smaller. For Ni–Ti alloy giving rise to the formation of monoclinic martensite, the recoverable strains and fatigue life are in between. But fatigue testing of R–phase is time consuming.

There is a continuous change in the shape memory characteristics of an SMA component with the operational cycles. The shape recoverability is the mean of the life of the SMA component. Shape recoverability is quantified by recovery stress and recovery strains. Of these two, recovery stress has more practical value since the performance of an SMA component is usually specified by the recovery stress at a fixed position.

For SMAs, their life is evaluated with respect to their repetitive operation involving a deformation followed by its recovery by heating. Fatigue represents the deterioration of the functional characteristics of the component, and is not restricted to its dimensional stability. SMAs do not fracture under normal conditions. It is, therefore, not a valid criterion for the fatigue life of the component.

R-Phase

In binary Ni-Ti SMAs, R-phase is formed by suitable thermomechanical treatments. But in ternary alloys based on Ni-Ti, if 2-3 wt.% Fe or Al is added to it replacing Ni.

The following methods (Strnadel, Ohashi et al, 1995) are used to obtain R-phase:

1. Introduction of rearranged dislocations produced by cold working then annealing at a temperature between 400 and 500°C.
2. Introduction of precipitate by solution treating followed by aging of Ni-Ti alloys with 50.5 at% Ni at 400 – 500°C.
3. Ternary additions like Fe and Al that suppresses martensite transformation.

R-phase is beneficial to actuation since it shows a smaller hysteresis width ($\sim$2K). The Ni-Ti alloys show a hysteresis width of 30-50°C. This transformation is called R–phase transformation (Dautovich and Purdy, 1965; Wang et al, 1965) since the lattice changes from cubic to rhombohedral upon transformation. Strictly speaking it is a trigonal phase. This phase is obtained by elongating (deforming) the cubic lattice along $<111>$ B2.

It is used for actuator applications, since it is associated with a very small temperature hysteresis.

Smart Car Concept

Today, the cars that are being manufactured abroad have smartness or intelligence built into them. These cars, called smart cars, exhibit what is called smart behaviour. A heavy downpour or snowfall makes the visibility poor and driving an arduous task. The lane

markers are either covered with a layer of snow or submerged under a pool of water. But incorporating a sensor system into the car helps detect the location of the lane markers and projects facsimilies of them onto the windshield. The driver immediately sees/knows where he/she is and whether or not he or she is on the right track.

The incorporation of smart materials also makes driving even in difficult climates or weather conditions easy and pleasurable.

If the engine of the car dies down completely while driving back home in a snowstorm, by simply pressing a button, a voice-activated cellular phone will transmit the car's exact location to a central emergency centre, which will immediately send help. The car's exact location is determined by radar and global positioning satellites (GPS), which are positioned uniformly high up in the atmosphere around the earth.

A recent study on road accidents shows that in the USA alone about 40,000 die every year due to car accidents. It is appalling to note that almost an equal or more number are either seriously injured or permanently maimed. But it is to be pondered that many of these accidents are caused not by reckless or drunken driving or by overspeeding but because of simple errors on the part of the driver.

In india, the number of automobiles plying on the roads is ever increasing with the entry of many multinational companies. The number of deaths due to road accidents is on the increase in the major cities in our country, too.

The implementation of mandatory rules on the use in cars of airbags and seat belts and lower speed limits for driving have reduced the fatalities to some extent. Sometimes, accidents are caused by distractions caused due to the use of mobile/car phones while driving, intoxication or sheer physical and mental fatigue. Driving cars long distances often proves to be monotonous. Human beings are generally prone to fatigue. This is one reason why computerization of the operation of cars has been under serious consideration for a few years now. There have been a number of proposals for computerized automobiles in recent times in developed countries. Some proposals have already been implemented on experimental cars.

Road accidents usually occur without much warning. The cars that are produced, especially in developed countries, are equipped with what is now known as smart technology. Not only do the smart cars have the capability to forewarn impending accident situations but also have safety measures built into them to prevent/minimize damage to human lives and automobiles. They use an altogether different approach to safety. They are equipped/designed to predict the likelihood of occurrence of accidents. They even give those extra few seconds to prepare for an accident and, in fact, even react before one actually occurs.

Cars produced in developed countries, are equipped with smart technology.

When the car swerves too much, the smart system gets activated so that it tightens all the seat belts, moves the front seats to upright and safe position, closes the sunroof and opens the windows. Whenever the cars swerve/drift from their lanes, they are warned by means of a rumble-strip noise. These preparations help reduce the probability of the passenger being ejected/thrown out of the vehicle.

The smart technology is equipped with ESP Electronic Stability Programme to sense/detect as well as prevent skids. They also incorporate (BAS) Brake Assist System. The conventional approach is to use airbags that cushion the blow once there is a collision. Safety aspects are given prominence in sports cars that have a higher probability of colliding/toppling. If the computer senses that a collision is likely, it will activate the deployment of airbags. This technology can tell the angle and position of the front seat occupants and the severity of the collision.

The objective is to avoid accidents altogether. Since it is highly improbable, the major objective then is to minimize the likelihood of casualties and damages to man and machine. This smart car concept is becoming popular now. The day is not too far when it becomes a reality.

Summary

Smart materials in general are used for a wide variety of applications: industrial, sport, defence, space, consumer and medical. Among smart materials, shape memory alloys are noteworthy since they possess the desired shape memory characteristics and mechanical properties that enable them to be applied in automotive applications. The shape rnemory alloys that find use in automobile applications are generally used as sensors and actuators. Actuators and sensors require shape memory alloys of different composition and temperature since they are used in different parts of the automobile. Alloys that are used currently have limitations as far as the recovery stress, recovery strain and temperature

range of applicability are concerned. They cannot generally be used beyond 100°C. There is, therefore, a need for alloys that exhibit recovery stress and strain and transformation temperatures in excess of 150°C. This has resulted in the development of new shape memory alloy systems, such as Ni-Ti-Cu, Fe-Mn-Si and Ni-Al. India has a long way to go in the area of application of smart materials in automobiles. But the application of smart materials in today's cars will lead to improved performance and return enormous dividends.

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Indian Car Dealers & Internet Technology

S.K. Majumdar & M.P. Gupta

This paper presents the results of a survey that was conducted to assess the perception, preparedness and experience of Indian car dealers in using internet technology. It exhibits the business portfolios, practices and attitudes of car dealers towards the usage of internet and web technology for managing their business. Ordinal and interval data were collected from 118 dealers. Single factor frequency tables, two factor contingency tables and multi-factor correlation matrix were constructed to understand the relationship between and among the factors of e-business readiness. Results show that those dealers with multiple business portfolios have the confidence to use the internet as an effective medium of doing business. A correlation is found between the firm's ability to develop its website and its capacity to attract customers through the internet channel.

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In 2002, the internet completed seven years in India. It offers a global interconnection of networks, enabling one to access any person, content or service that has an online presence or address. It is a medium that can carry data, content, voice or video, depending on the bandwidth available, enabling flexibility of use, diverse applications and services. The more utilitarian these are, the more it will be used. The concept has made a good beginning in India, and holds a lot of promise for the world of business, which is already witnessing profound changes under its influence. Customers, suppliers, distributors and business partners are getting connected via the internet and conducting business transactions using computer networks rather than physically visiting the market. A good review of literature on e-commerce is reported by Ngai and Wat (2002). The viability of electronic-commerce depends on several critical factors such as the availability of internet connections, a vendor's ability to transform physical processes to online ones, and the existence of a sufficient number of online buyers. The internet is certainly a global information dissemination technology, but the commercial viability of its application for a given market depends on the local condition of the operating market. It certainly allows companies to gain tremendous operational efficiencies, personalization, and information based products and services. Therefore, e-commerce must be pursued carefully as a strategic initiative rather than as an appendage to an existing organization (Chang et al 2002).

In this context, a study of the Indian car industry is the most apt topic, since it is, at this very moment, undergoing an extraordinary transformation. The pressure of competition is compelling carmakers to explore new technologies and processes to remain competitive in their chosen segment. From the early days of Henry Ford to the present, the car industry has always been receptive to new ideas, technologies and processes that inspire innovation, and which lead to new product development, thereby providing superior value to customers. The technology that promises to integrate

diverse business processes, distant business-partners, customers and service-providers in one thread, and allows its users to expand the boundaries of their business, improve relationships and develop global markets is the internet technology (Porter 2001). This powerful technology has removed the needs of intermediaries and is allowing the manufacturers, distributors and service providers to communicate directly with their distant customers, thereby altering the forms and processes of manufacturing, distribution and service industries and converting them into eBusiness. It has transformed the procurement and retailing processes of the auto industries of US, Germany and Japan into eProcurement and eRetailing (AT Kearney, 2000). Global car companies such as Ford, GM and Chrysler, harnessing the power of the internet have created a global arm to collaborate, communicate and conduct business transactions with their partners, suppliers, dealers and customers. They have developed internet-enabled business processes and are reforming the production and retailing systems of the automotive sector. The e-Business processes provide efficient and timesaving tools for seep up information from customers to manufacturers and suppliers (Dawar and Frost 1999).

Global car companies such as Ford, GM and Chrysler, harnessing the power of the internet have created a global arm to collaborate, communicate and conduct business transactions

Yet, the concept of selling a car has remained largely unchanged for years. A recent study shows that car buying behaviour of different nationals is different. In USA 70% of all prospective car buyers use the web to research a car purchase (www.TheStandard.com, 2001) and 33% of buyers use eBusiness facilities for car purchase, while in France, only 3% use eBusiness services for car purchase (www.atkearney.com). These studies indicate that though the scope of the internet is global, its impacts on different geographical locations are different. Harvesting the benefits of the internet requires understanding the implicit *cultural inclinations* of the target customers. This paper conducts a survey of 118 car dealers in India in order to assess their perception and preparedness in using internet technology for managing their business. Further, it reports the results of both exploratory and confirmatory statistical analysis of dealers' data, which include frequency tables, chi-squares, cluster analysis and cause and effect analysis, as well as statistical analysis such as Duncan's mean range test, t-test and correlation analysis.

Research Design

The research design enumerates the questions of the research, the instruments of data collection and the procedures that were followed to collect and analyse the data. This study addressed two research questions. These questions are:

- What are the states of diffusion of internet tools and technologies among the car dealers in India?
- What are the socio-demographic characteristics that have a significant influence on the attitude and behaviour of Indian car dealers towards the use of eBusiness processes?

Since both the internet and eBusiness are in a state of growth, there is little past data to formulate a hypothesis. Therefore, the construct of the study is exploratory in nature, and examines the present overall picture of Indian eBusiness as well as the socio-demographic characteristics of buyers and dealers of cars and their attitudes about eBusiness. The prime concern of this study was to understand to what extent internet technology has and would likely transform the role of Indian car dealers.

The population size of car manufactures is 14, whereas that of authorised dealers is in the thousands; and millions of customers are scattered all around the country. The design of data collection method had to decide the frame of the survey, techniques of sampling, ways of collecting data and the sequencing of data collection activities.

The dealers' sample frame included only the authorised distributors of the companies residing in the five metropolises. Attempts were made to interview the representatives of all passenger vehicle manufacturers. For carmakers, the heads of marketing, IT departments and production department personnel were considered as the ideal representatives of the company.

The collection of information or data can take place using mail questionnaire, telephone interview, or face-to-face-interview. Though the mail questionnaire is less costly, the response rate is very low. It was therefore decided to collect information through direct interviews.

The uniformity of information was considered important. Sometimes questionnaires were mailed or delivered earlier while fixing an appointment. The telephone was used to fix appointments, to brief people on the context and purpose of the interview and to check inconsistency or eliminate doubts after the com-

pletion of the collected process. This direct interview helped to clarify the purpose and objectives of the study and instant resolution of doubts, which, in turn, generated a higher response rate.

Since data had to be collected from multiple sources and from various cross-sections of society, to ensure that the same type of information is obtained from each person, across various organisations and territories, it was decided to have structured questionnaires with maximum number of closed questions and a few open ended questions. The open-ended questions permitted the interviewer to probe and explore within these predetermined inquiry areas. The structured interview questionnaire ensured good use of limited interview time, while interviewing multiple issues of eBusiness in a more systematic and comprehensive manner, and helped to maintain focused interactions.

The dealers' questionnaire was also divided into three sections.

- The first section dealt with the profiles of the business, the number of years they have been in business, annual sales turnover and dealerships handled. It then covered the details of customer visits, i.e. the reason they perceive why a customer selected them, the number of visits made by customers before purchase on an average, the type of information sought on these visits, other services provided by them and their advertising media, if any.
- The second section dealt with their perception of the Internet and of electronic business and the present status of the business in that regard. This was done by looking at their awareness of eBusiness, how important they perceived the various advantages and disadvantages offered by eBusiness to be, their previous experience with it, if any, and their opinion of the effectiveness of the internet as a medium for information and communication.
- The third section looked at their future plans in the field of eBusiness. This covered their plans regarding their website, the perceived advantage of having one, and the factors encouraging and dissuading them from transacting through the internet, as well as the perceived future of e-commerce in the Indian car market.

This questionnaire was intended to look mainly into the Business to Customer (B2C) segment of online business transactions. It relied mainly on multiple-choice questions and scaling with very few open-ended questions. It aimed to find out what factors customers consider while purchasing a car, and the dealers' use of the internet as a medium of communication and selling and the perceived advantages and disadvantages of its use. It also intended to see what factors would encourage them towards greater use of e-commerce in their transactions. This helped us to understand the readiness of dealers to use eBusiness in their transactions. This has importance, as dealers link the customers to the manufacturers, and therefore, even if customers are seen to be positive towards eBusiness transactions, the carmaker can exploit the situation only if the dealers are equally positive about the spread of eBusiness. Quantitative analysis software SPSS was used in this study to assist in data analysis.

Even if customers are seen to be positive towards eBusiness transactions, the carmaker can exploit the situation only if the dealers are equally positive.

The effectiveness of the interview questionnaire was improved by seeking an expert's opinion. The survey questionnaire went through several iterations of expert panel evaluation review by the case firm, and a technical pilot study for operational testing. The questionnaire used standard measuring scales for collecting numeric data (interval data) about the variables of the research.

The technique of multiple research methodology was incorporated to increase the validity and reliability of the findings. Confirmatory statistical analysis was conducted to uncover the presence of statistically significant empirical evidences about the attitudes and acts of the customers, dealers and carmakers towards e-Business processes. Detailed fact finding case studies were undertaken to ensure the validity of the findings.

Characteristics of data

Comprehensive information on the profiles, preferences, and practices, which includes details about the intents, driving factors, experiences, expectations and future potentials of eBusiness, was gathered retrospectively during structured interviews with the managers of authorised dealers of cars. A pilot study project phdcar.com was developed to refine the questionnaire, by interactively querying the fitness and rationale of the questions.

The information gathered from the survey was decomposed, transformed and tabulated to examine to

what extent the retailers of cars are ready to use internet technology for their businesses. Several single factor frequency tables were drawn to understand retailers' preferences, perception and commitment to use e-Business technology for retailing of cars. Contingency tables were constructed to reveal the associations and relationships between any two factors being analysed. This helped to build theories from the observations. Furthermore, the social research data software SPSS was used to conduct exploratory and confirmatory statistical analysis of collected data to find the relationship among various factors. The demographic profiles of the respondents describe the frame and composition of the sample.

Key questions

The dealers are the "middle men" of the carmakers. They are responsible for listening to the needs and preferences of car-customers and assisting them in selecting the desired model from the available options.

The questions that this survey intended to address were:

- What are the business portfolios of Indian car dealers?
- What eBusiness initiatives have the car dealers taken?
- Is there any relationship between car-dealers' presence on the web and doing business on the internet?
- How do the eBusiness attitudes of the managers of car-dealers affect the eBusiness preparedness of the car-dealers?

Analysis and Discussion

The samples of this survey were drawn from the dealers' list of five metropolises (Delhi, Mumbai, Kolkata, Bangalore and Hyderabad) as given in the All India Dealers Directory 2000. A total of 118 dealers responded to this survey and provided valid data inputs. Table 1 shows the demographic profiles of participants.

Several single factor frequency tables were constructed to exhibit the results of the survey, while bivariate contingency tables and multivariate correlation matrix were constructed to understand how the experience of internet selling influences the individual's e-Business perception and, finally, how eBusiness perception of managers affect dealers' eBusiness preparedness. Frequency tables are widely used for looking at data. Of the frequency tables that we examined, only those are presented here that displayed meaningful insights about the behavioural or eBusiness practice patterns of the retailers of Indian passenger cars, or those frequency tables that have a significant link with the objectives of the study.

Table 1: Demographic Profile of Responding Dealers

Cities/Towns	Number of Participants	Percentage
Delhi	28	24%
Mumbai	32	27%
Kolkata	14	12%
Bangalore	14	12%
Hyderabad	30	25%
Total	118	100%

Business Portfolios of Dealers

The business profiles of the authorised dealers are shown in Fig. 1. It exhibits certain aspects of the dealer's business that may or may not have been obvious from common knowledge, but which certainly required some statistical recording. Looking at Fig. 1 it becomes evident that dealers operate a multifaceted business. A significant percentage of the participating dealers not only retail passenger vehicles for a patron car manufacturer(s), but are also service providers and component suppliers. As many as 37% of dealers were also service providers and 15% of the respondents also authorised suppliers of components.

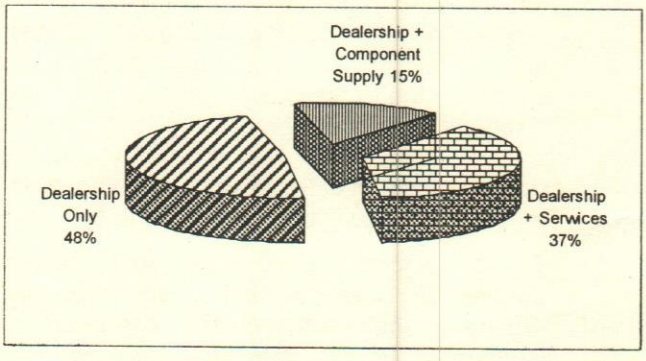

Fig. 1. Business Profiles of the Respondent Dealers

Apart from the authorised dealers, there are, generally, separate service stations and authorised spares parts shops for every carmaker.

Fig. 2 shows the number of years a dealership has been operating, which is possibly commensurate with the experience and their level of comfort in the market in

many cases. However, in saying that we see immediately that most dealers, 55%, have been in the business for less than seven years. The explanation for this is the entrance of many new carmakers in the Indian market over the last five years.

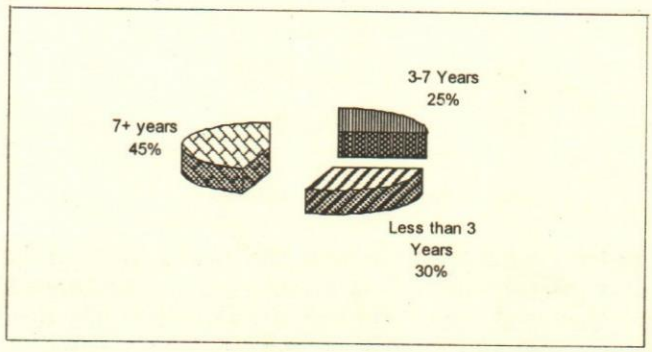

Fig. 2. Age of Business

The link between a particular city and the profile of the dealers is negligible.

Multiple Cars Dealership Options

Figure 3 shows how dealers are keen to expand the scope of their business. Some dealers who have been extremely successful have decided to expand their horizons by selling cars for several different carmakers. From the table we can see that about 66% of the dealers are willing to go for multiple car dealerships, provided car companies allow them to do so.

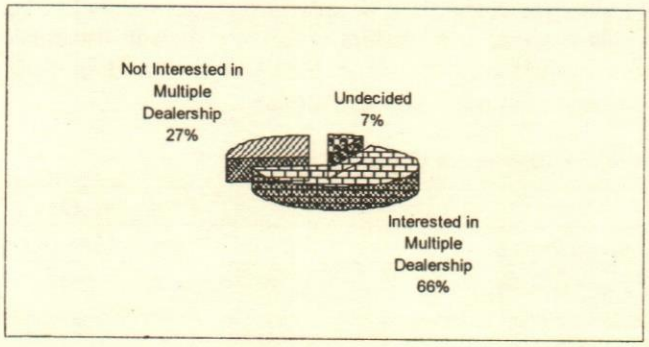

Fig. 3. Multiple Car Dealership Options

The trend towards expansion could very well be helped by the increasing influx of a host of foreign companies into the Indian market, and the ensuing intensified competition. Subsequently the consumer now has no dearth of choices when looking to buy a car, and the dealer is responsible for selling the customer his/her desired vehicle. It may happen that because of a depressed demand for a particular make of car, the dealer might not be able to realise enough sales to sustain the dealership. To guard against such a perilous situation, dealers often want to give their customers a choice of at least 2-3 brands.

As for the dealership option, it has been observed that the effect of age of business and the city are not significant. This is consistent with other data because the choice of the dealership depends on the carmaker rather than a particular dealer. Carmakers are supposed to have a policy concerning issues of multiple dealership branches. Of the 27% dealers who responded in the negative, it was observed that most of these dealers were company owned dealerships with their entire infrastructure provided by the carmakers. Therefore, the dealers can be classified into two distinct types: (1) authorised dealers and (2) company owned dealers. The company owned dealers would continue as sole retail outlets of their patron carmaker until there is a mutual understanding amongst carmakers to allow a company owned dealer to sell other carmakers' products.

Business Portfolios of Dealers

Table 5 shows that most car dealers have multiple revenue sources. The other common revenue sources for dealers are (i) selling car accessories and spare parts, (ii) selling car finance and insurance schemes for financial institutions, and (iii) providing repair and maintenance services.

Figure 4 exhibits that 87% to 93% of the authorised dealers also sell car finance and insurance schemes of financial institutions and that 81% of the dealers sell car accessories.

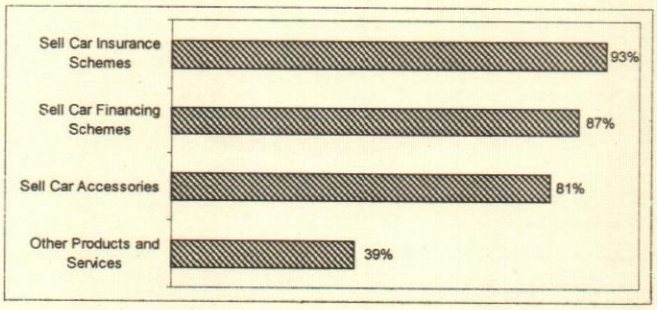

Fig. 4. Other Businesses of Car Dealers

Except in Delhi, in other cities, the majority of dealers retail car accessories and spare parts. In the case of car finance and car insurance, most dealers in Delhi provide these facilities, whereas this is not true for other cities. It is also to be noted that the volume of car sales is the highest in Delhi, where car finance and insurance schemes act as process facilitators by providing conveniences for customers. In other words, the

availability of finance and insurance schemes at the point-of-sale is likely to boost car sales.

Unique Selling Features of Dealers

Figure 5 exhibits that 93% of dealers believe that trustworthiness is the attribute which customers often search for while selecting a particular dealer. The second most important attribute, according to the dealers, is accessibility.

Figure 6 shows that 80% of customers make two to three visits to the dealers' show room before placing an order. This input indicates that if customers get an opportunity to study the product profile beforehand and if it could cut the average number of visits to two instead of three, it will save customers' time as well as increase car sales person's productivity by 33%.

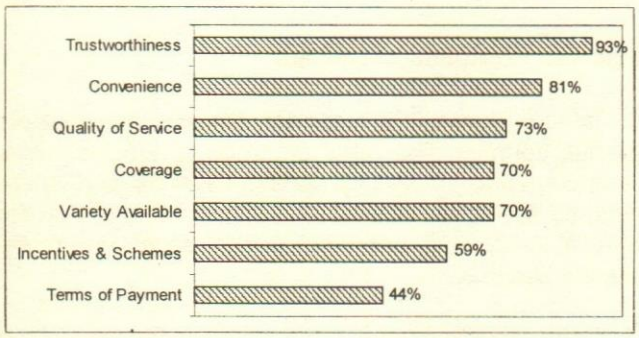

Fig. 5. Dealers' Opinion about Customers' Value Perception

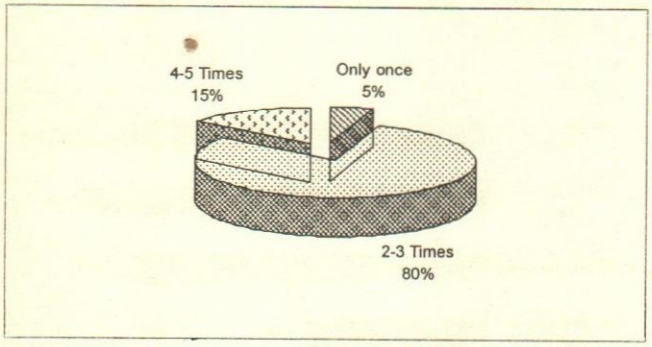

Fig. 6. Number of Visits a Customer Makes

Figure 7 reveals that the most frequent enquiry, which 97% of the dealers quoted for their customers, is information about the price of a model. Other frequent queries are about model features (87%) and comparisons (84%) between other models.

Online Business Awareness

It was observed that 107 out of 118 (91%) of the

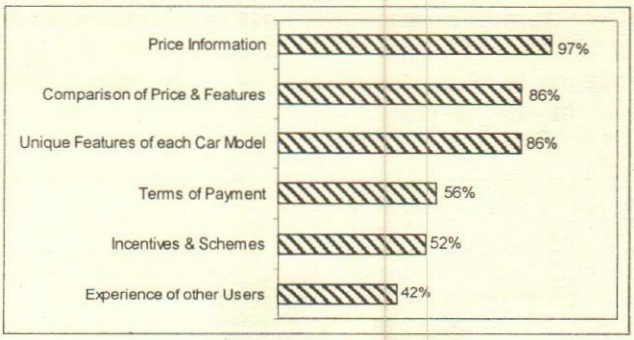

Fig. 7. Frequently Asked Inquiries by Buyers

dealers are aware of the potential of eBusiness; 98 out of 119 (83%) were willing to advertise on the internet, and 26 (22%) out of 118 had actually taken this step. There is clearly a disparity between the number of people willing to utilise resources on the internet and the number that have already gone ahead and done so. The responses to question 24 reveal that 102 out of 118 (86%) of the dealers felt that the internet is a good medium to spread awareness. It is evident that car dealers are aware of the enabling power of the internet, and this awareness is getting transformed into real e-Business initiatives.

Development of Websites

Having a website is considered as the first step of an eBusiness initiative. Market penetration can only begin after the creation of an online presence. Table 2 shows that nearly 53% of dealers already had websites of their own at the time of survey (i.e., June-July 2000). In this respect, the dealers who were also in the business of providing services (50%), are ahead of their component-supplying peers (39%).

Table 2: Web Presence of Dealers

Dealers		Have Websites	
Business Profiles	Count	Count	Percent
Dealership + Services	42	21	50%
Dealership Only	58	34	59%
Dealership + Component Supply	18	7	39%
Total	118	62	53%

Many Indian car dealers have realised the enabling power of the World Wide Web. In fact, about 53% already had websites when they were surveyed, while of the remaining 47%, about 46% had plans to launch a website within the next 6 months-1 year. If the growth rate is maintained, it is reasonable to presume that by 2001 end, 76+% of dealers will have their own website (see Table 3).

Table 3: Progression of Web Penetration

Dealers Type	Percent Progression of Web Presence		
	July 2000	+ 6 Months	+ I Year
Total	53% (62)	64% (76)	76% (90)

Experience in Online Selling

Figure 8 shows that 14% of dealers have already experienced selling on the web. This low percent is not really a point of concern. What is important, however, is that 53% of Indian dealers have already secured their presence on the web, and some of them have started doing online business.

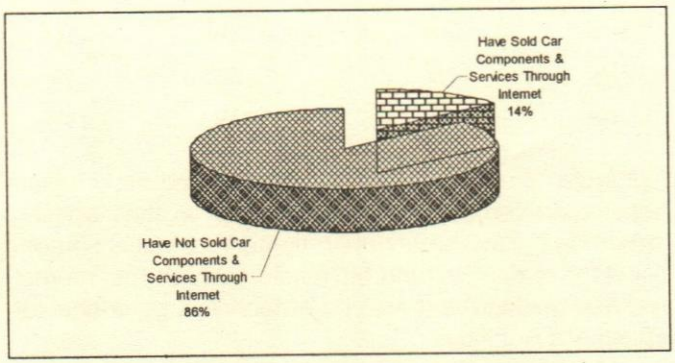

Fig. 8. Experience in Online Business

A closer look at Table 4 shows that 26% of the dealers who have taken the internet initiative, by creating a web page, have started doing online business in some form or the other. There is no significant difference across the classes of dealers, except in the case of component selling dealers. This could be due to late entry of this category of dealers into the act of creating online business facilities.

Table 4: Transition from Web Presence to Online Business

Dealers		Made Web Presence	Done Online Business	
Business Profiles	Count	(Have Their Website)	Count	Percent
Total	118	62	15	26%

The results of the survey also reveal that none of the dealers had any bad experiences, while doing business transactions over the internet.

Perceived Benefits of Online Business

The results of the survey show that car dealers are aware of the advantages of having websites and the benefits of online business. The majority of the dealers believe that a website increases visibility, improves service delivery and raises the boundary of business. Fig. 6.9 shows dealers' perception about the benefits of online business.

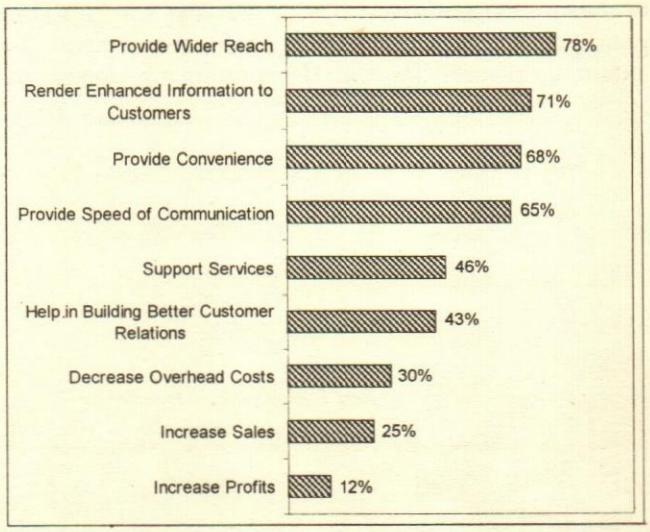

Fig. 9. Perceived Benefits of Online Business

Figure 9 shows that 78% of dealers believed that online business increases their market reach and as a natural corollary, delivered better product information to their audience. A high percentage (around 65%-68%) also felt that the internet provided them with a convenient and speedy way of doing business, while adding value to their service for their customers. These were the advantages that dealers, in general, considered the most important, but better customer relations and support services were also paid significant attention. However, the dealers were not certain about the increase in profitability and volume of sales. This indicates that revenue streams of eBusiness are not known, which presumably is the factor that is hindering the growth of online business in car retailing.

Perceived Inhibitors of Online Business

Figure 10 shows dealers' opinion about the current difficulties of online business. The two major issues that the dealers felt needed to be addressed for a healthy growth of online business were security and reliability of payment systems. The third factor that is creating difficulties to traditional business units is the technological complexity of online business processes.

Form the positive responses of the dealers, it seems that they are enthused by the prospects of the internet, and many of them are already co-habitants of the physical and virtual market. Yet, by scrutinising the figures of

those who have actually managed to realise any sales or other benefits, one may doubt the potential of e-Business in the Indian car industry. Nevertheless, keeping in mind that it is just the starting out point for many of the dealers on the web, this is no big surprise. Judging from the large number of dealers who are preparing to make an online market presence and within a short period of time, it is quite conclusive that the majority of Indian car dealers are ready to conduct eBusiness.

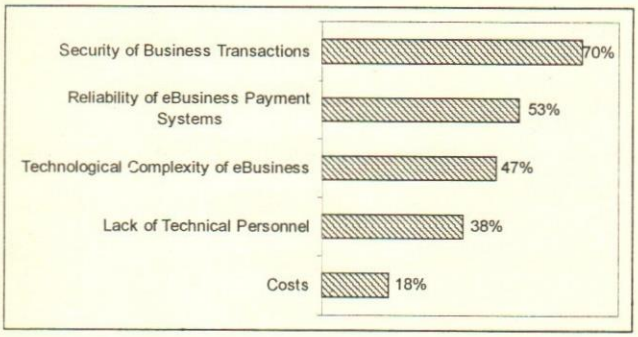

Fig. 10. Inhibitors of Online Selling

Statistical Analysis of Data

In previous sections, single factor tables displayed the state of eBusiness initiatives as well as perceptions of car dealers towards eBusiness. Each factor describes a separate characteristic, attitude or behaviour of the dealers towards the use of internet technology (eBusiness). Contingency tables and multivariate correlation matrix were constructed to understand the impact of the socio-cultural factors of the car-retailing business on the adaptation of internet and eBusiness technology.

The following sections present the results of statistical analysis of dealers' data.

Two Factor Contingency Tables

The construction of contingency tables provided clues of existence of several cause and effect relationships. The statistical significance of those relationships was subsequently verified by conducting multivariate correlation analysis. Tables 5 and 6 present the comparisons of experienced and inexperienced online selling dealers' opinions about the reliability of eBusiness payment systems and availability of technical persons.

Table 5 indicates that dealers' experience in internet selling makes a difference in the level of their confidence in eBusiness payment systems. The Net-Selling dealers' level of confidence in eBusiness payment systems is higher than that of the Non-Net-Selling dealers.

Table 5: Reliability Perception of eBusiness Payment System (Percentage)

Sold Through Net	Agree that the eBusiness Payment System is Fully Reliable	Do Not agree that the eBusiness Payment System is Fully Reliable	Total
Yes	62.5%	37.5%	14%
No	53%	47%	86%
Total	54%	46%	100%

Table 6: Availability of Technical Personnel (Percentage)

Sold Through Net	Agree that getting Right Technical Personnel for eBusiness is Difficult	Do Not agree that getting Right Technical Personnel for eBusiness is Difficult	Total
Yes	44%	56%	14%
No	37%	63%	86%
Total	38%	62%	100%

Table 6 indicates that experienced and inexperienced internet selling dealers differ in their opinion regarding the availability of competent technical personnel. 44% of dealers who have sold through the internet feel that getting the right type of technical personnel for eBusiness is difficult.

The experienced dealers' opinion carriers much more weight than that of the inexperienced ones. However, it is to be noted that the chi-square test failed to identify any significant difference between the experienced and inexperienced internet selling dealers' perceptions about the reliability of eBusiness payment systems as well as the availability of technical personnel. Perhaps the sample was small and not good enough for the chi-square test.

Multi-factor Correlation Analysis

Multivariate correlation matrix was constructed to uncover the relationship between the car-retailing mangers' attitude towards eBusiness and the actions taken by the dealers to construct their websites, and also to understand the relationship between the car dealers' construction of website and generation of business through internet. Table 7 presents the results of correlation analysis. The results of correlation analysis show that those who believe that eBusiness has a bright future are of the opinion that eBusiness has many advantages and that the internet can be used as an effective medium of doing business. The level of significance is 0.01. Secondly, the dealers who sell accessories, finance and insurance schemes are convinced about

the media potential of the internet. The level of significance is 0.05.

Table 7: eBusiness Preparedness Correlation Matrix of Car Dealers

	F1	F2	F3	F4	F5	F6	F7
F1	1						
F2	0.09	1					
F3	-0.07	0.29**	1				
F4	0.15	0.3**	0.36**	1			
F5	-0.08	0.04	0.22*	0.09	1		
F6	-0.1	0.09	0.12	0.15	-0.08	1	
F7	-0.14	0.02	0.02	-0.09	0.09	0.28**	1

* Significance at 0.05 level ** Significance at 0.01 Level

F1 = Age of Dealer's Business

F2 = Manger believes that eBusiness has many advantages

F3 = Manger considers that the internet is an effective media/channel for business

F4 = Manger believes that the eBusiness future of India is bright

F5 = Dealers who also sell accessories, finance and insurance schemes

F6 = Dealers who have sold their goods and services through the internet

F7 = Dealers who have developed their websites

Surprisingly, the eBusiness Preparedness Correlation Matrix indicates that there is insufficient evidence to conclude whether there is any relationship between car-retailing mangers' attitude towards eBusiness and the actions taken by the dealers to construct their websites.

The answer to this surprising conclusion presumably lies within the characteristics of the dealers' organisations. In fact, most of the Indian car dealers are small family owned business organisations rather than professionally managed organisations. The mangers are rarely authorised to make strategic decisions. They can provide factual business information of their business. Probably, this is the reason why the correlation analysis did not find significant evidence of correlation between mangers' attitude towards eBusiness and organisations' action towards the co-habitating, both in the physical and virtual markets. Table 7 shows that there is a significant correlation between "dealers who have sold goods through the internet" and the "dealers who are visible on the web". The level of significance is at 0.01. This indicates that the dealer's capacity to attract customers through the internet depends on its ability to make its presence felt on the virtual market. The presence in the virtual market (development of Website) is a precursor of virtual selling. Website increases a firm's visibility; and increased visibility enhances the firm's capacity to attract internet customers.

Concluding Remarks

This paper presented the analysis of the portfolios of car dealers' business, their managers' attitudes towards eBusiness, actions taken to make their virtual presence and the experience they have gained in e-Business. The results of data analysis reveals that 66% of dealers would like to go for multi-dealerships. A majority of car dealers also sell schemes of Car Insurance, Car Finance and Car Accessories. 53% of those who responded already had their own websites and by the end of 2001, more than 76% of dealers will have their own websites. More than one fourth of the dealers, who had their websites, had experienced the taste of internet selling. 78% of dealers believe that the major advantage of eBusiness is "wider reach", but are uncertain as to whether this will increase the profitability of the company. The contingency table reveals that experienced internet selling dealers have more confidence in eBusiness payment systems than their inexperienced counterparts. The statistical analysis revealed that dealers with multiple business portfolios believe that the internet can be used as an effective medium for doing business. Secondly, there is a correlation between the firm's ability to develop its website and its capacity to attract customers through the internet channel. A website increases the dealers' visibility, and increased visibility increases the dealers' capacity to attract customers through the internet.

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IT Enabled Manufacturing Process Design

R. Anandh

The introduction of new products has become the way to sustain and grow in today's competitive and globally spread market. A typical new product introduction cycle starts from conceptualization and goes through design, manufacturing process design, pilot and then ramp up. (A best practice is to make the design and manufacturing process design parallel, wherever applicable, in order to cut down the cost and time of new product development). This paper mainly focuses on discrete manufacturing process design with an emphasis on automotive parts.

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One of the key elements of this new product development process is manufacturing process design. Manufacturing process design is concerned with identifying the sequence of steps in converting the design into actual part. If product engineering tells "What to produce" and production planning tells "When to produce", manufacturing process design tells "How to produce" the product.

1. Time to market
2. Quality of the part and
3. Cost of the part, are the key parameters for measuring the efficiency of new product development. Manufacturing process design has a direct bearing on all the three.

Diversity in the manufacturing operations, the high frequency of new product introduction, outsourcing trends, disparate information sources and formats are the challenges faced by the manufacturing process design. Information technology can play a vital role in improving the efficiency and effectiveness of the manufacturing process design function by:

1. Automating certain repeated tasks. (Providing standards for rough machining, grinding, etc.)
2. Creating visibility in the manufacturing design process, by integrating disparate sources of information. (Information from design, quality, production, etc.)
3. Enabling collaboration between various stakeholders. (Intra company collaboration between manufacturing and design etc and inter company collaboration between company and vendors, etc.)

As a result, Information Technology plays a very important role in manufacturing process engineering, thus improving the overall efficiency of the new product design.

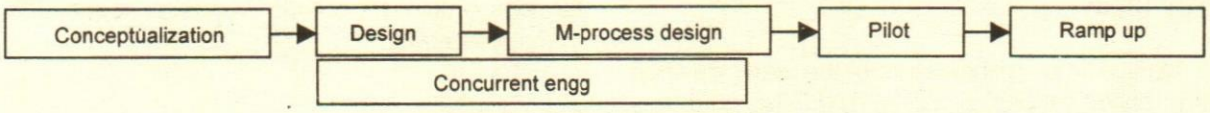

Fig. 1. New product development process

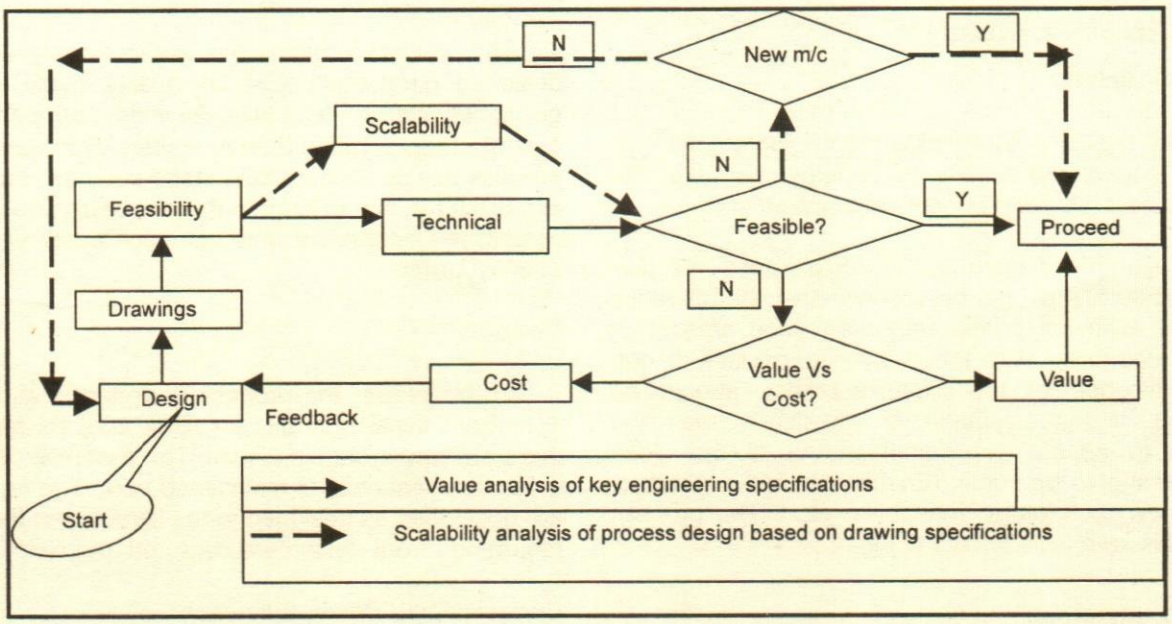

Fig. 2

Manufacturing Process Design:

In this competitive market, one of the ways companies attract customers is by introducing new models and products. Manufacturing process design is one of the critical steps in new product development as shown in Fig. 1.

Merriam Webster dictionary defines "Process" as "a series of actions or operations conducing to an end". Going by this, manufacturing process is a sequence of steps or operations that converts design drawings into end items. Manufacturing process design is concerned with devising this sequence of manufacturing operations, by considering various factors such as manufacturing technology, capacity, production volume, etc.

Manufacturing process design can be grouped broadly into four phases with distinct activities in each. They are:

1. Study phase:
   a. Part study
   b. Feasibility study
2. Design & planning
   a. Process design
   b. Facilities planning
3. Establish
   a. Pilot
   b. Ramp-up
   c. Corrective and preventive action
4. Transfer
   a. Handover to production

Study Phase

Part study

In this study phase, the manufacturing engineer would study the details of the drawings. This includes studying and understanding of the part functionalities, the impact of geometrical / design specifications on the functional aspects, and its criticality in the overall functioning of the product. For example, the squareness of gears with reference to the shaft is important for wobble-free and smooth functioning. In short, this involves the understanding of the significance of the various specifications of the part given in the drawing in the overall scheme of things.

Feasibility Study

The feasibility of manufacturing the part, meeting the design specifications, consistently, is studied in this phase. Feasibility study is carried out from two broad perspectives. They are:

- Technical feasibility
- Scalability

These are done by considering the factors such as existing capacity available, technology available, the value vs. cost, addition of new capacity, etc.

For example, if there is a close tolerance in a particular product, it should be seen whether the tolerance could be achieved consistently with good amount of process capability, with the existing capacities. If not, the significance of the close tolerance should be evaluated. If the tolerance is significant, then the decision to *enable* the manufacturing of the close tolerance should be made. (Enabling includes introduction of new technology, machines, etc.). The process flow of this step is as shown in Fig. 2.

Design & Planning

Process Design

The details of how the part is to be manufactured are specified here. The details include the sequence of operations, the facilities required (equipments, tools and gages, etc.), the cycle time planned. These details are recorded in the form of process sheets.

There are two approaches for process planning:

1. Zero based approach: wherein, the process is designed right from scratch.
2. Reference-part family method: wherein, the advantage of similarity of parts is leveraged.

The selection of the manufacturing process is the key element in this step, and it depends on factors such as production volume, available production capacity and the quality levels. Also, the design of appropriate material handling equipments is done at this stage.

Facilities Planning

The designed process can be effectively implemented through proper selection and planning of facilities. Facilities include equipments, toolings, cutting tools, gages and others required for manufacturing. The key activities in this stage include identifying the facilities required, potential vendors, negotiation, order management, etc.

Establish

Pilot

The process engineer has to prove the process for designed parameters such as quality, cycle time, ergonomics, etc. In this phase, the individual step is concentrated more, rather than in entirety. For example, the process design may contain steps such as rough turning, finish turning, drilling. In this step, each operation is established separately and not necessarily in the sequential order.

Ramp-up

In this phase, the process designed is established right from initial operations to the end, to observe if there are any systemic issues. The essential difference is that the sequence is maintained here. The equipment are positioned as designed in the layout, and the issues regarding layout design are captured and resolved.

Corrective and Preventive action

This step is so tightly integrated with the pilot and the ramp-up stage that this cannot be treated as a separate step in the entire manufacturing process design. Nevertheless, in order to avoid duplication, and considering the importance of this step, this is introduced. Various problem solving techniques and guidelines such as 8-D (8-Discipline problem solving approach) are used here to capture and solve the problem. This could be a great learning for future process designs.

Transfer

Handover

Typically, in auto industries, the production function would be separate from the manufacturing design function. As the volume of the new product increases, and once the process design has been established, the next step is to handover to production and other stakeholders such as maintenance as well. In this, the key element is transfer of information relating to design, manufacturing, equipment, vendors, toolings, gages, quality plan, etc. To give a perspective, once this handover is made, the Manufacturing Execution Systems or ERP would take over the planning, scheduling, production and shipping and not the manufacturing process design.

Ergonomics: Also known as Human Factors engineering ergonomics is the study of fitting jobs to people. This includes studying comfort and safety factors in the work environment.

Layout: The arrangement of equipment and other facilities in a plant in such a way that it facilitates easy flow of material, information and people movement.

Toolings: This is a general term, which includes jigs, fixtures, etc. to clamp, guide and orient the part, in a machine.

In performing these activities, manufacturing process design has to interact closely with many other functions in the organization. These include design, production, maintenance, industrial engineering, purchase/vendor development, etc. The complexities are in the nature of information required by various stakeholders, and the format in which this information is available.

The significance

Manufacturing process design has significant bearing on cost, quality and the time available to market a new product. The choice of manufacturing processes, the flexibility of the process design, the technology involved, all contribute to the cost, quality and the time to market the product.

Cost: The design of manufacturing process has a direct impact on the cost of the product. The choice between automation/manual, computer controlled versus legacy machines, Special Purpose Machines (SPM) versus General Purpose M achines (GPM) has a direct bearing on the cost of the product.

Quality: To provide consistent, predictable quality, process design plays a major role, right from the selection of operations, equipment, fixtures and other toolings.

Time to Market: As we have seen, manufacturing process design is one of the value adding partners in the new value chain of new product introduction. The time to market is dependant on the extent of information available to the manufacturing process engineer on real time basis.

Asset Utilization: Manufacturing process design helps to improve asset utilization by reducing the investments in floor space, fixtures and tools. It helps in achieving the improved throughput and reduced cycle time, thereby, providing sufficient capacity to meet customer demands.

Profit Margin: Proper Manufacturing process design, helps in increasing profits by

- Reducing scrap in operations
- Providing standardized instructions and hence less training costs

Six Sigma Performance Requires Linking Manufacturing Process Design: In simple terms, the goal of Six Sigma is to improve the ability for the manufacturing process to produce a consistent product well within the design specifications - the result being improved product yield and a consistent product shipped to customers. Therefore, the linking of product and process design activities ensures that any change is visible to both the design and manufacturing communities.

Key challenges

The key challenges in the process engineering and management function are:

1) Managing multiple stakeholders for various information needs (Both information from the stakeholders and for the stakeholders as well)
2) Disparate information sources and systems (such as ERP, drawings, manuals etc.)
3) Multiple information formats (various versions of CAD, ERP, etc.)
4) Change management: flexibility to respond to design changes, customer needs and varying production volumes.

Figure 3 shows the various stakeholders involved, their information needs and the sources of that information.

Managing multiple stakeholders

The manufacturing process design has to interact with other functions such as:

Design: for value-cost analysis, understanding of the parts.

Vendor: to understand their manufacturing processes and to incorporate the best practices in manufacturing of parts supplied by the vendors. Moreover, assistance to vendors in terms of process improvements, toolings, process audits, etc. is also common. Apart from this, a close interaction with vendors of material handling equipments is essential for planning material handling equipment.

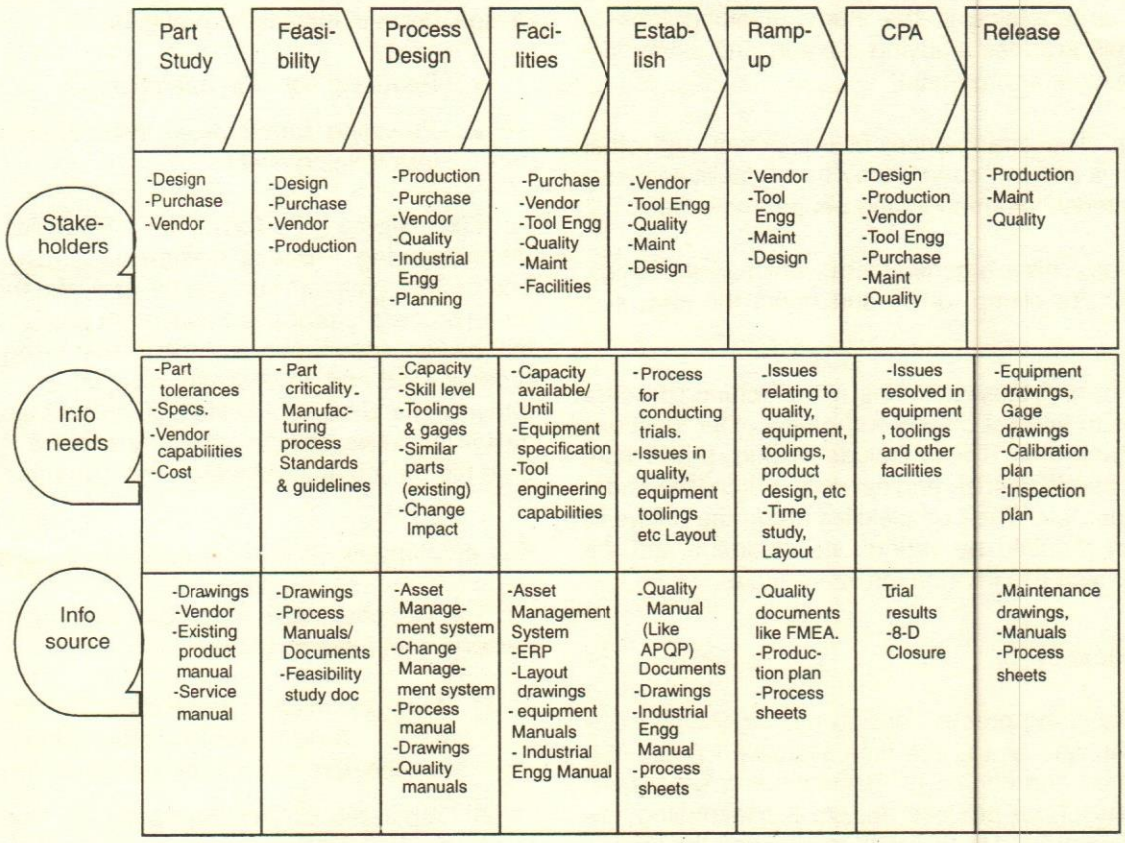

Fig. 3. Stakeholders, their information needs and source or information

Purchase: To understand the capability of various vendors, to potentially evaluate the opportunities for outsourcing, in order to create capacity or to reduce costs.

Production: To understand the manufacturing process of similar existing parts, so that the best practices can be carried over and also the lessons learnt. A very close interaction with production is essential, as they are the end customers for the process design. In addition, the information regarding the CAM programmes and toolings is required from production.

Maintenance: In certain cases, process design might lead to equipment purchases. Maintenance is involved in finding out the existing issues with those kinds of equipment so that the issues are not repeated.

Industrial engineering: The key element in manufacturing process design is the estimation of cycle times, as this determines the number of equipment required, given the volume of production. So, a close interaction with the industrial engineering functions would be required in order to estimate time standards, based on various Industrial Engineering techniques such as Micro motion study, Predetermined time standards, etc.

Tool Engineering: Parts cannot be manufactured without the availability of proper jigs and fixtures (jigs and fixtures are the ones which hold [clamp], locate [guide] and orient the part in the equipment so that the operations can be performed effectively). Tool engineering is the function that designs and manufactures the toolings required for the process design. So, a close interaction with tool engineering is necessitated. In many cases, the toolings are also out sourced. This again requires a close interaction with vendors regarding the same.

Quality: Manufacturing engineer would require interacting with quality to establish the calibration standards for gages, the procedures for conducting trials and new part introduction such as adhering to QS 9000 standards.

Figure 4 shows typical interactions with various agencies/functions for various information needs.

Disparate sources of information

The information related to part, vendor, capacity, cycle time, toolings, facilities, layout, quality standards, etc. are available in various sources. Some of them are

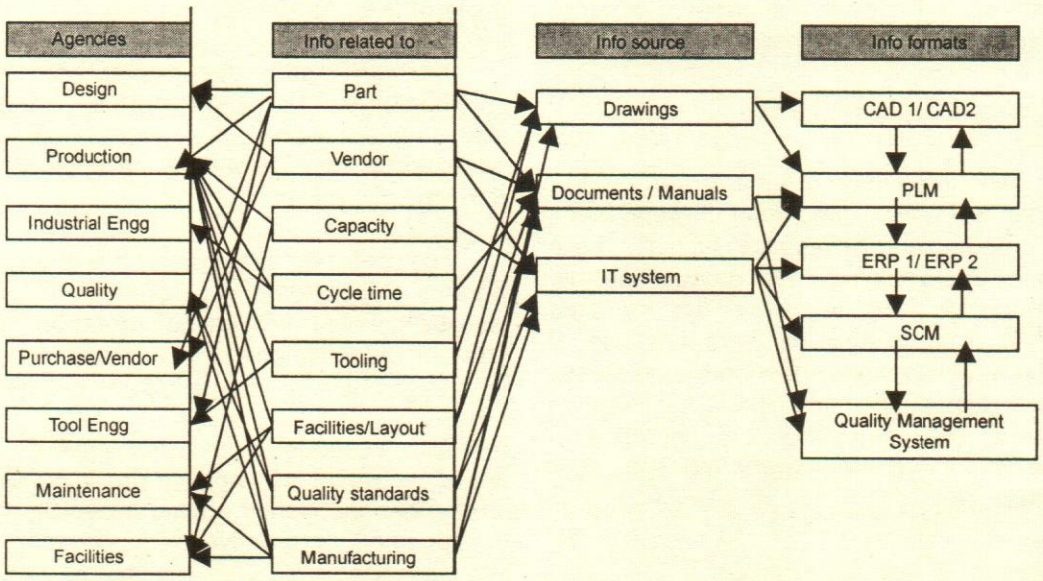

Fig. 4. Interaction between agencies/functions

available in IT systems such as ERP, and some in drawings and in the form of manuals. The visibility of this information in real time is critical to good manufacturing process design and also to reduce the time taken to market the new product as also its cost.

Figure 4 shows the interaction between the information required and the possible sources of the information.

Broadly, information regarding the following is critical in shortening the time taken to market the new product and in reducing the cost of the part.

Part: Information regarding the existing part, the issues faced in the manufacturing process design of existing parts are valuable in leveraging the knowledge to avoid reinventing the wheel. This drastically reduces the time to market and cost by attempting to design the process right the first time.

Vendor: Information regarding the capability of outsourcing would provide valuable lead towards cost reduction. This becomes more important with more and more vendor base (with increased outsourcing) and vendors being geographically scattered.

Capacity: Information regarding asset utilization is useful in decision making regarding capital goods procurement. This has a direct bearing on the cost of the product. Also, capacity related information could be used as a sourcing decision. For example, if there are two manufacturing plants, and if the capacity of gear shaping is available in one of them, then till ramp up period, the parts may be decided to be shipped from the other plant. Thus, this has a direct bearing on the time taken to market the new product.

As per AMR research, every year, manufacturers invest millions in plant and equipment, often not knowing what resources are available or where they can be used.

Cycle Time: This is used to determine the yield and the number of equipment that would be required. If information regarding cycle time is not available, then it could lead to costly wrong decisions such as under utilization, low productivity, etc.

Tooling: If the manufacturing engineer has the design of toolings for the existing part, then the feasibility of using the same or rationalizing the same with the existing product can be studied.

This will drastically reduce the cost and hence time to market the new product, as toolings are either readily available or available after slight modification instead of ground up manufacturing.

Production: The knowledge of various manufacturing technologies being used in existing parts, across plants can be leveraged for cost benefits. For example, the results of production trials for alternate processes done in a plant can be leveraged in another for cost and time to market benefits.

Innovation Management: Companies try to improve the quality or reduce cost through various innovations and new ideas. These experiments and the results are to be tracked and made visible to all stakeholders in order to reduce cost and improve quality and shorten the time to market.

Figure 4 shows the disparate information sources and their interaction with the different stakeholders.

Multiple information formats

Within the various sources of information, the formats could differ, warranting integration between them. For example, automobile companies typically have more than one CAD package for product design. Automobile companies have their own IT systems such as multiple ERP from multiple vendors because of reasons such as growing by mergers and acquisitions, geographically distributed scenario, organization restructuring, etc. This is another key challenge in having an integrated information flow or visibility.

Change Management

Changes in part design can happen for typical reasons such as change in customer needs, product quality improvement, manufacturability, maintainability, etc. The manufacturing process design has to respond to these design changes quickly in a manner that does not affect the total time to market. The change management should be happening simultaneously and not in a sequential way, in order to compress the time to market the product. In addition, the impact of these changes to multiple entities, multiple information sources needs to be studied. If say, for example, a fastener specification is changed by the design team for better functionality, the same information has to be updated in part drawings, process sheets, assembly drawings, operators' instruction sheets, inward quality plan/manual and service manual.

Changes in part design can happen for typical reasons such as change in customer needs, product quality improvement, manufacturability, maintainability, etc.

Also, the information has to be co-ordinated with the vendor along with the purchase function. With these disparate IT systems and with information in different formats, managing the change for smooth transition becomes another key challenge in manufacturing process design.

This is not only restricted to design and manufacturing but also to other stakeholders as well.

Role of Information Technology

The challenge of disparate sources and formats of information can be handled through **integration** of the various information-sources and formats so that the information is visible to various stakeholders in a real time scenario.

The challenge of managing the information needs of various stakeholders, including change management, can be handled through **collaboration** network. Thus, the above challenges can be abstracted into two key challenges namely, integration and collaboration.

Also, business process management, coupled with workflow, would add value in providing solutions to the challenges mentioned above, especially in the change management perspective.

Integration

Integration is the ability to share the data/ information between various applications and people.

While industry standards are still evolving in standardization across product data exchange (such as ISO 10303 - Standard for Exchange of Product Model Data STEP), many automotive companies have, by this time, numerous CAD applications, which need to be integrated.

A single platform or portal for integrating these would help to provide part related data to the manufacturing process engineer.

Another integration required is in the area of IT applications. For reasons described in this paper, there are many IT systems such as ERP from different vendors in different databases, SCM systems varying from vendor to vendor and also within the plant. Enterprise Application Integrators can integrate these various information source and formats. In a broader perspective, applications such as ERP, EAM, SCM, CRM need integration within and across applications.

Collaboration

This is a natural step, once the data is available in an integrated format.

IT can provide a collaborative framework wherein all the stakeholders can work in tandem to accelerate the product development process itself. With globalization of operations, organizations can leverage the time difference between different geographies and hence reduce the time to market the product. Real time and near real

time information can be shared through e-mail, secure instant messaging, voice communications, and video conferencing, Private Trading Exchange (PTX)[b], etc.

Also, collaborative sharing of documents in real time is another critical aspect. This enables the appropriate stakeholders to work simultaneously in their own areas of interest. For example, a material handling designer can work on the drawing with the outer dimensions, a cutting tool designer can work on the specific cutting tool required to manufacture and so on.

(Read Annexure 1 to see how IT can help in each of the steps in the process design right from part study to handover)

In short, IT can add value to the manufacturing process design by,

1) Providing better response to changes in design, customer needs, and production volumes.
2) Providing better visibility of real time data regarding part, capacity utilization, quality, cycle time, etc. which are critical for the time taken to market the product as well as its cost.
3) Providing better collaboration platform to various agencies by integrating information from various sources and thus enabling easy information exchange.

The Market

Manufacturing Process design softwares are still evolving in the market place. The primary reasons for restraint in growth is the lack of awareness.

Integrating with PLM

As per Frost & Sullivan, the key drivers for this solution would be, cost savings, products to market faster, integrating information, globalization of manufacturing, system upgrades, and ageing workforce, many of which we have seen in this paper. The relative rankings over a 10 year period is given in Table 1.

These requirements are either addressed fully or partly by various software products. Some of them integrate with the PLM solutions, others offer as point solutions.

For example, IBM with Dassault system is the market leader in this segment, coupled with PLM solutions. Another product company, Tecnomatix, has recently formed an agreement with EDS PLM solutions to connect EDS's PLM integrator, allowing the companies to synchronize design and process data.

Table 1: Market drivers ranked in the order of impact- 2001 to 2011.

Rank	Driver	1 to 3 years	4 to 6 years	7 to 10 years
1	Cost savings	High	High	High
2	Product to market faster	High	High	High
3	Integrating information	Medium	Medium	High
4	Globalization of manufacturing	Medium	Medium	Medium
5	Systems upgrade	Low	Medium	Medium
6	Ageing workforce	Low	Low	Medium

Source: Frost & Sullivan

Some of the point solution products are *Polycapp*, *Proplanner,* etc.

End User Market

The major contributor for revenue growth in the MPM software is the automotive industry, which would account for more than 40% of the total revenues over a period of 10 years. The industry is expected to grow at the rate of about 34% every year until 2011.

When OEMS such as FORD and GM and tier ones such as Delphi and Visteon embrace this technology, MPM software will see an accelerated growth.

Conclusion

IT can play a major role in manufacturing process design, which is a key element in new product introduction. However, there are challenges in IT enabling the manufacturing process design function.

There is a growing need for uniform standards for the information exchange from various sources towards integrating, especially product related data. XML plays a major role in providing a standard and attractive way of information exchange.

In addition, the other challenge is the change in the mindset of the design and manufacturing communities to work with half finished information, in order to reduce time to market.

Integrating the growing number of vendors in real time scenario is going to be another challenge in the long run.

The nature of manufacturing process design widely differs from one industry to another. The manufacturing process design for discrete manufacturing is entirely different from process industries such as oils, chemicals, etc. Even in discrete manufacturing industries, the manufacturing process design is different between project environment, mass production environment, etc. "One size fits all" does not apply. So, the applicability and the value add should be thoroughly evaluated before IT enabling the manufacturing process design.

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Frost & Sullivan (2001), Research Report - MPM Market Primed for Robust Growth.

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Annexure 1

Product Study

IT can play a key role in this in the following ways:

- Visibility and access to the drawings and design to the concerned process planning engineer in real time, or as practically close to real time as possible, by capturing the process planning team information and linking with the engineering bill of materials. (Bill of resources)
- Visibility and access to the design Failure Mode and Effect Analysis. (FMEA)
- Visibility of similar products or parts (within the company and across locations).
- Version management and change management: Capturing the history of changes coupled with workflow could be the value adds by IT.

Feasibility Study

- A database of similar parts manufactured with the company would help in identifying the issues associated with those parts. This would help in taking appropriate preventive actions or corrective actions, well in advance. A strong part numbering system is a basic necessity across the company to identify the 'similar parts', and IT can provide the same.
- The IT system can help in maintaining the manufacturing feasibility document for the parts that are under design. (Maintaining means creation, exchange among key stakeholders, version control, etc.)
- Visibility to manufacturing feasibility documents to design engineers and also to manufacturing process engineers would help in first time right design, which is again a major factor in shortening the time to market.

Process Design

IT can play a key role by providing real time information from various sources and formats regarding,

- *Capacity:* Once the manufacturing process engineer identifies the machine that would be required to convert design into physical part, the system can provide the information of all the machines available, with the capacity numbers in the geography, where the new product is planned. The user should be able to do the analysis across all related geographies where manufacturing facilities are located for similar parts. This would help the process engineer to select within available machines or to plan for new machines.
- *Toolings and gages:* From the nature of similar parts, the system can suggest the toolings and gages along with their usage, and drawings. This would enable the manufacturing process engineer to leverage the existing toolings and gages and also to make sure that all "re-usable" options are exhausted before a decision to make or buy new toolings is done.
- *Timings*: As part of the process design, the manufacturing engineer needs to establish the timings to manufacture the part, split into machine timing and manual timings, value added timings and non-value added timings, etc. The system can provide inputs regarding,
  - The timings of similar parts and the database of time measurement techniques such as Therbligs, micro motion study, etc.

Facilities Planning

IT can help in supply chain planning and execution in the asset procurement cycle and also in preparing the optimal layout design, considering factors such as space utilization, ergonomics, etc.

- Supply chain: IT can play a role in planning and execution of various orders for facilities and also in the supply chain integration.
- Layout design: IT can also provide the layout of the existing facilities, so that the 'fitment' of new facilities and the re-arranging of layouts can

also be planned well in advance. This avoids re-work and hence cost reduction.

Establish & Ramp-up

The process designed needs to be established for planned cycle time, quality and flexibility.

IT Imperative: Document/Knowledge Management

- The system can provide features to record the initial quality issues, its root causes and timings. Also, the system could capture the corrective actions taken.
- The maintenance of such documents transforms into knowledge management, which would be then used for future process engineering, thus reducing the chance of the same issues repeating.
- Also, the lessons from similar parts can provide valuable insights to the manufacturing engineer and help in shortening the time to market cycle.

Hand-Over

Typically, the manufacturing engineering function would be separate from the routine production function. Once the process design is established, the same needs to be transferred to production along with the process design and knowledge.

- IT can provide and maintain a checklist with applicable/relevant items for handover to production, so that physical assets and knowledge assets are transferred without any gaps. For example, based on process engineering, IT can create a book of knowledge which includes, machines, their manufacturer's contact, its maintenance manual, drawings and everything related to machines. The same holds good for toolings and gages. In addition, the system can provide details regarding the safety stock of critical toolings available at the time of productionizing.

Quality Management

Quality has to be built in the product. So, quality has to be focused right from the conceptualization stage. There are quality frameworks such as Advanced Part Quality Planning (APQP) of QS 9000 for new product / process introduction and 8-Discipline (8D) problem solving framework. IT can integrate seamlessly with manufacturing process management.

Change Management

IT can play a key and prominent role in change management. IT can exchange knowledge and thus make visible, the changes that have taken place in the product design to various stakeholders in near real time basis. In fact, some of the changes might require redesigning the manufacturing process afresh, i.e. right from product study. IT can leverage on the workflow and other process systems to design and effect the changes.

Vendor Management

IT can play a prominent role in collaboration in the following way:

1) Exchange of product related information, drawings based on the access rights.
2) Maintain the database of vendors with the parts they supply to various projects, geographies.
3) Vendor process quality assessment framework- such as process quality assessment initiative, assessment reports, etc.
4) Vendor trials recording framework - trials initiation, trials process, trial results, etc.

Overall-Metrics

The system can also provide the time spent by manufacturing process engineer in a project, in the various steps given above. This is useful in many ways:

1) This also can provide key insights in improving the time to market and also in reducing the cost of introduction of new products. For example, if in two successive projects it is found that 60% of the time is spent in facilities planning, then it gives an insight to management that the collaboration framework between various stakeholders such as vendors, toolings, etc. needs to be strengthened. Another example, if the time spent is more in 'product study' phase or in 'feasibility study' phase, then there is scope for training the manufacturing engineers in the product/drawings study.
2) Also, this is useful in arriving at benchmarks of the time taken between various activities and arriving at the proper work content. For example, process design should take 20% of the entire project, 'establish' phase 10%, etc.

Simulation

IT can provide simulation tools for the manufacturing engineer, which can be used for optimizing the cycle times of manufacturing.

□

Focus

Integrating Supply Chains through UNIDO's Partnership Programme

George B. Assaf

This article discusses the UNIDO Partnership Programme in light of the need for small and medium scale enterprises in India to integrate with global value chains. The article focuses on the informative industry and how relevant issues have been dealt with comprehensively through UNIDO's Business Partnership Programme.

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Today, all around the globe, industries, particularly manufacturing industries are undergoing restructuring and transformation at a speed that would have been unthinkable a few years ago. Rapid liberalization of trading and investment regimes across the world and the development of communication and information technologies are opening new opportunities of global business partnerships. At the same time, these unprecedented developments are posing enormous challenges.

Within this new broad global paradigm, the current global economic context is not too bright. Global recession has not yet passed. And, some of the major economies of the world—led by the largest, the United States, are still not totally out of the doldrums.

In this not-too-bright context, the need for Indian enterprises, particularly small and medium scale enterprises, to integrate with global value chains in rapidly restructuring industrial scenarios, is even greater. There are, of course, a few significant pre-requisites for this to happen.

First, it is essential to recognize that competition is no longer local but global.

Second, quality, cost and technology—the most important requirements for competitiveness—are the drivers of today and even more so in the future. It is quality that keeps a customer's confidence. But since customer expectations are changing rapidly, there is a constant challenge for manufacturers to focus on winning customers through innovative technological solutions. It is important to note that both quality and technology help achieve the cost reductions required to stay competitive.

Third, competition and cooperation can go together and invariably need to go together in the current structure of fiercely competitive global markets. The auto component industry is one industry where this is an in-

creasing global reality. Cooperation is the key to staying competitive. This cooperation can be within an industry or across industries, among SMEs themselves, or between SME suppliers and their buyers.

The paper first focuses on the global automotive industry. The global automotive industry is undergoing a rapid transformation process. As the market pressure on vehicle manufacturers or Original Equipment Manufacturers (OEMs) increases because of declining profitability and changing consumer tastes they are, in turn, increasing the pressure on their suppliers in terms of price, quality and services. In addition, with 'Tierisation', there are changes in the supply system and structure. The number of parts, components and systems that are outsourced by vehicle manufacturers is increasing continuously. This tendency has led to the growing prominence of suppliers in the automotive industry and changed the relationship between OEMs and suppliers, as well as among suppliers themselves.

Not surprisingly, these changes are affecting the Indian industry as well. A number of large international Tier-1 suppliers have set up bases in India and are supplying modules to vehicle manufacturers. Some of these Tier-1 suppliers include Delphi, Visteon and many others. As a consequence, Indian component suppliers, in particular, SMEs, need to link up with these Tier-1 suppliers if they are to survive. In this respect, cost, quality and delivery of components, are of utmost importance.

In response to these developments and challenges, and mindful of the significant benefits to be drawn from a constructive goal-oriented partnership between the business community and the UN, UNIDO has launched an innovative approach called the UNIDO Partnership Programme. The Programme aims to build partnerships between major private sector actors – industrial corporations and institutions, developing countries' governments and institutions, and UNIDO itself. The programme aims to contribute to global development objectives. As a part of this UNIDO initiative, an agreement was forged in November 1998 for the automotive component sector of India. The Programme partners were the Government of India, Fiat S.p.A. through Magneti Marelli, INSEAD, the International Business Leaders Forum (the former Prince of Wales Business Leaders Forum), the Automotive Component Manufacturers Association of India (ACMA) and the Automotive Research Association of India.

UNIDO Partnership Programme aims to build partnerships between major private sector actors – industrial corporations and institutions, developing countries' governments and institutions, and UNIDO itself.

The objective of UNIDO's Partnership Programme, in support of the Indian Automotive Components industry, is to improve the structure of the sector and to enhance the performance of domestic SMEs by transforming them into globally competitive suppliers. This Programme pioneers an ambitious multi-sector partnership with clear benefits for all the partners involved. The build-up of efficient domestic supporting industries in this sector will bring:

- Additional productive employment and income generation
- Increased local production and, as a result, reduced import requirements; and
- Broad technological and managerial learning effects.

Most importantly, the Programme takes advantage of the wealth of know-how, technology and experience of each partner. These will be used as building blocks for formulating and delivering an integrated package of support services. Through a solid demonstration approach, expert advice in areas such as productivity enhancement, quality upgrading, and supply chain management, will be provided to selected enterprises.

The involvement of the most important institution of the automotive component sector – that is, the Automotive Components Manufacturers' Association or ACMA – will ensure effective dissemination and wider impact of specific advice and support, rendered at the company level. UNIDO itself brings to the programme its proven global experience and multi-dimensional expertise, as well as its existing networks. Experts from reputed organisations bring their knowledge and expertise in responsible business practices, global benchmarks and best practice solutions for SMEs in the automotive component sector to help improve their competitiveness in international markets. Thus, each of the partners plays an important and distinct role within the Partnership. Only the combination of the particular strength and expertise of each of them would guarantee the sustainable success of the Partnership Programme for the lasting benefit of SMEs.

Phase I of the Programme, in which 20 companies from the Western Region of India participated, demonstrated that the approach taken by the Programme was able to yield concrete results at the enterprise level by achieving significant and measurable

improvements at the shop-floor level. In less than one year, the Programme achieved impressive results in terms of increases in turnover and productivity, safer production methods, better use of existing machinery and equipment, and an enhanced awareness of the need for continuous improvement. During Phase I, the average lead time required for completion of products was reduced by 52 per cent; the amount of shop floor training grew from almost 0 to 238 hours per month; absenteeism dropped by 39 per cent; the application of standard operating procedures rose by 54 per cent; and production space grew by 25 per cent.

The first phase of the Partnership Programme in 1999 focused on bringing about non-capital changes in enterprises by using world-class manufacturing methods and disseminating "good house-keeping" practices. After the completion of Phase I, ACMA built on these achievements with complementary initiatives. All these efforts have enriched our experience, and the lessons learnt have an important bearing on the focus and direction of our future initiatives.

In May 2000, in the context of the project, a Review Mission to the Western Region was undertaken. This review confirmed not only the results achieved in 1999, but also revealed a clear change in the mind set of entrepreneurs and managers in most of the participating companies. This was quite an achievement. Changing people's mind-set is probably the most difficult task. The Partners deemed Phase-I of the programme as timely and well-structured in an environment of ever-increasing competition in the automotive component industry in India. This was an environment where some 50 per cent of the existing enterprises in the automotive component industry sector are expected to disappear within the next three to five years.

As a follow up to the successful pilot programme in the Western Region of the country in 1999, UNIDO and its partners have launched a nationwide programme. The programme enables small suppliers to improve their competitiveness and thereby, gain access to national and international supply chains.

The programme enables small suppliers to improve their competitiveness and thereby, gain access to national and international supply chains.

What is the specific 'partnership' approach we have taken in the programme? The format of the current Programme, too, is based on the multi-sector UNIDO Partnership Programme approach, integrating the Government of India, the Automotive Component Manufacturers Association of India (ACMA), and UNIDO. It is foreseen to integrate over time, vehicle manufacturers and Tier-1 suppliers as well. India now has the presence of almost all major vehicle manufacturers in the world today. The most notable of them are Ford, GM, Volvo, Hyundai, Toyota and Honda. It is envisaged to constitute a Business Advisory Group comprising the vehicle manufacturers, Tier-1 suppliers and component manufacturers to oversee the implementation and content of programme services.

As of now, the responsibility for the coordination and management of the Programme rests with UNIDO. The other partners are contributing to the Programme by way of expertise, administrative support and cash, towards part reimbursement of programme costs.

The Programme has built a strategic alliance with the Confederation of Indian Industries (CII), which has enabled the design and development of a model. This model functions as the generic base for adaptation by small and medium-sized enterprises.

Phase II of the Programme has been designed based on the experiences and lessons learnt in Phase-I. The emphasis in Phase II is on institutional capacity building. The Programme will also work closely with local institutions to build a cadre of Indian engineers who will be able to provide technical advisory services to SMEs in the automotive component sector. For this purpose, a number of mentoring and training activities are envisaged.

One of the distinctive features of this Programme is the full ownership and active participation, including financial participation, of a large number of important companies. Another important focus is on enhancing quality, as it has been said by one industry analyst, "The race for better quality has just begun. It is certainly not over".

The objective of the UNIDO Partnership Programme Phase II is two fold:

First, it seeks to enable small and medium manufacturing enterprises in the automotive sector in India to improve their overall competitiveness, and, thereby, to integrate successfully with national and international supply chains.

Second, it tries to build institutional capacity for serving SMEs in the industry concerned. While in-

dividual SMEs will benefit from practical programme services, the approach will also emphasize training of local engineers to enable a wide outreach to an increasing number of small and medium-sized manufacturers, reducing, thereby, the average cost per company served.

Programme services are being offered through a team of four National Experts or Counsellors. The Programme envisages development of generic training modules on 'Best Practices', customized for use by SMEs. These would be updated periodically. Content level knowledge of the counsellors is being calibrated through regular and periodical refresher modules. The National Experts provide on site guidance and facilitate the participating companies in implementing recommended processes and practices. During their shop floor interventions in the participating companies, the National Experts help develop model areas/machines. Following the Cluster Approach, regular review meetings of these companies are held, in which they share their learnings. The entire package of inputs would be offered within a period of 30 months.

In terms of monitoring and evaluation of the Programme, a baseline survey of participating companies has been carried out at the beginning on the following indicators:

- Number of defective parts per million
- Labour productivity
- Stock turnover
- Delivery schedule achievement
- Overall equipment effectiveness
- Value added per person
- Floor space utilization

Training inputs are directed towards improvements in these indicators.

As of now, UNIDO has positioned National Experts for four regions – in Delhi in the North, in Pune in the West, in Chennai in the South and in Jamshedpur in the East. The programme has been initiated for 40 companies in these four regions. The Programme will attempt to give inputs according to a detailed phased schedule.

However, actual inputs would depend upon the progress and performance of participating companies. Programme inputs may also include topics such as Total Productive Maintenance (TPM), Awareness of Lear Manufacturing, etc.

While implementing the programme in India, UNIDO faced the problem of lack of availability of trained counsellors and experts. The Programme envisages training SME managers/engineers in best practices that include elements of Just-in-time (JIT), TQM, TPM and so on. Although, there are industry experts available in the country who have the required expertise, these are limited to the Vehicle Manufacturers and some of the big Tier 1 suppliers. Smaller component manufacturers do not have easy access to these qualified experts who are not only few in number but are also expensive.

Although the Partnership Programmes have attempted to make available the services of these experts to the 40 selected companies, the requirement is for much more.

One of the objectives of the programme (long term) is to build capacity in terms of making available trained manpower to the Indian Automotive Component industry. Towards this end, UNIDO is seeking to integrate vehicle manufacturers in the programme. Almost all the major vehicle manufacturers in the world have set up their manufacturing bases in India. Integrating them would help design programmes that are more relevant to the industry.

UNIDO will also attempt to link up with training institutes, such as engineering colleges and polytechnics who provide the industry their requirements of engineers, shop-floor managers and supervisors. UNIDO would also help design better programmes that are more relevant to the industry. □

We are what we repeatedly do. Excellence then is not an act but a habit.

– Aristotle

Feature

Single Assembly Line Balancing Problems

C. Murali Krishna, M. Chandrasekaran, Aveek Das & Rupak Dey

Line balancing is concerned with assigning individual work elements to various workstations to increase line efficiency. Several contemporary assembly line heuristic methods viz., Largest Candidate Rule (LCR), Ranked Positional Weight Technique (RPWT), etc., were available for line balancing. This paper analysed a single model – serial assembly line problems under different heuristics, and shortcoming have been identified. A new comprehensive method (CoM) for line balancing has been proposed. Performance measures such as line efficiency, balance delay, number of workstations, cycle time/ production rate, etc., have been used for comparing CoM with LCR and RPWT, with the help of five sample problems.

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Line balancing is concerned with assigning individual work elements to various workstations to increase line efficiency or reduce the balance delay, increase the production rate, thereby minimizing the unit assembly cost. The basic concepts in line balancing are to divide the total work content into minimum rational work elements and allocating to various workstations, satisfying precedence requirements of those elements. Historically, assembly line balancing leads to two types of problems. Type I problem attempts to minimize the required number of work stations with the cycle time remaining constant. Type II problem attempts to minimize the cycle time for increased production rate (Baybars, 1986). In practice, line design process involves solving these two problems sequentially. In the first phase, we find the minimum number of workstations required to assign all the tasks so as to meet the target production rate. In the second phase, we try to reduce the cycle time for the same number of workstations.

Several contemporary assembly line heuristic methods are available for line balancing. But no significant investigation is made in the literature to compare these techniques. This paper analyses two commonly used heuristic methods viz., LCR, RPWT, for single model assembly line balancing problems.

The limitations of different heuristics were identified and a comprehensive method has been devised. The application of CoM is checked by solving example problems and a hypothetical problem is illustrated with solution procedure.

Heuristic Approaches To Line Balancing Problems

Many heuristic approaches to the line-balancing problem have been proposed. These methods are based on experimentation rather than mathematical optimisation. Here we analysed two commonly used heuristic approaches viz., Largest Candidate Rule and Ranked Positional Weight Technique for single model assembly line problems. The limitations of these methods are identified.

Largest Candidate Rule Method

This method of line balancing as described by Moodie and Young, 1965 follows:

Step 1: Arrange elemental task (T_{ek}) in descending order of their elemental times.

Step 2: Assign the element to the i^{th} workstation satisfying

- precedence requirement among the elements.
- station time (T_{si}) must be less than or equal to cycle time (T_c)

$$\text{i.e., } T_{si} = \sum_{k \in i} T_{ek} \leq T_c$$

Ranked Positional Weight Technique

This is one of the best-known heuristics introduced by Helgeson and Birnie. This method requires computation of Ranked Positional Weight (RPW_k) for each task. Let S(k) be the successor of elemental task 'k', then task IS(k) implies that I cannot begin until k is complete. RPW_k is calculated by summing T_{ek} and all other elements' times that follow T_{ek} in the precedence diagram. The procedure is as follows:

Step 1: For all tasks k = 1,2,3... n, compute RPW (k). Arrange the tasks in descending order of RPW (k)

Step 2: For ranked task k = 1,2,3,...,n, assign task 'k' to the first feasible workstation. Open new work stations as and when required.

Other Rules

A common way to choose tasks is by using the task with the most following tasks. Some times top priority is given to the task that takes the least amount of time. In some of the methods, least number of following tasks is also considered. Other well known heuristic methods include Kilbridge and wester method, COMSOAL, Moodie and Young, Hoffman procedure, Immediate update first fit and assign heuristics methods.

Limitations

The limitations of the heuristics considered are:

a) In LCR method, Interdependency of elements is not given any importance for allocation of tasks.

b) In both the above heuristic methods, LCR and RPWT, there is no provision to improve upon the solution obtained.

Comprehensive Method

Assumptions

The comprehensive method (CoM) of assembly line balancing described in this paper is based on the following assumptions:

- The line is of a single model suitable for only one type of product.
- The elemental task time may be less or equal to the cycle time.
  Mathematically, max $T_{ek} \leq T_c$, k = 1,2,3...n
- All workstations are provided with required number of tools/equipments to carry out the elemental tasks allotted to that station.
- No zoning constraint is allowed.
- The line is linear.
- Repositioning time for all the workstations remains the same.

Solution procedure

Step 1: Draw the precedence diagram with the given information.

Step 2: Identify the independent elements for each of the elements based on precedence requirement. The element neither precedes nor succeeds the chosen element, it is said to be an independent element for that chosen element.

Step 3: Compute the Independency weightage (IW_k) for each element which is the sum of it's task time and task times of all its independent elements (k_x),

$$\text{i.e., } IW_k = T_{ek} + \sum_{kx=1}^{nx} T_{ekx}$$

where n_x is number of independent elements.

Step 4: Consider the ready tasks. A ready task is any task that has had its precedences met. If more than one ready task is present, consider the one which has least IW for allocation. In case of same IW for two or more ready tasks, select the convenient element for allocation.

Step 5: Cancel the element, which has been allocated. Consider the new ready tasks, which satisfy the precedence relationship. Go to Step 4 and repeat the allocation process till all the elements are allocated to the workstations.

Table 1: Information about task times and precedences for example application

Task code	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Task time(T_{ek}) in seconds	55	30	50	42	20	25	45	60	36	42	30	40	36	40
Predecessors	–	A	A	A	–	–	A,E,F	B,C,D,G	H	H	H	J	J	I,K,M,L

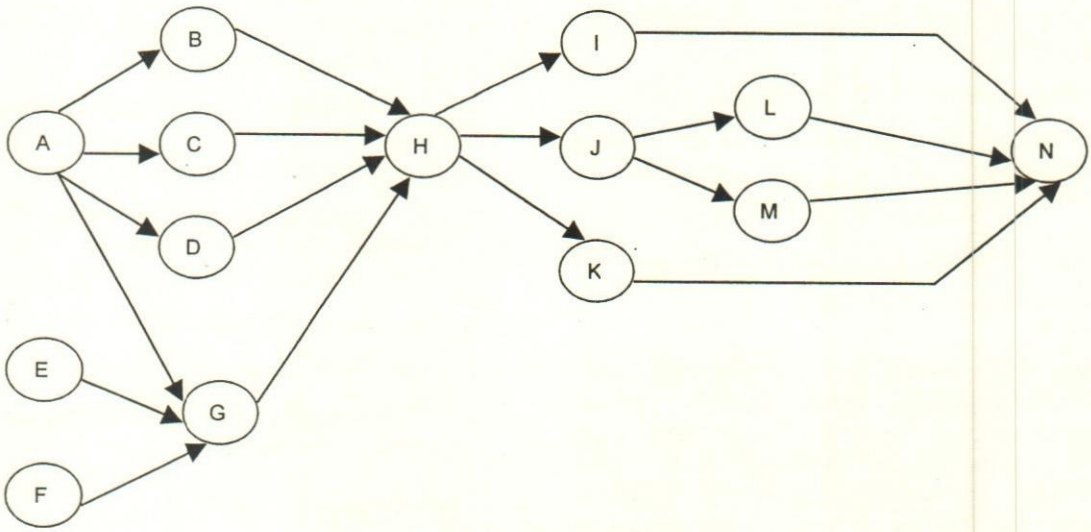

Fig. 1. Precedence diagram

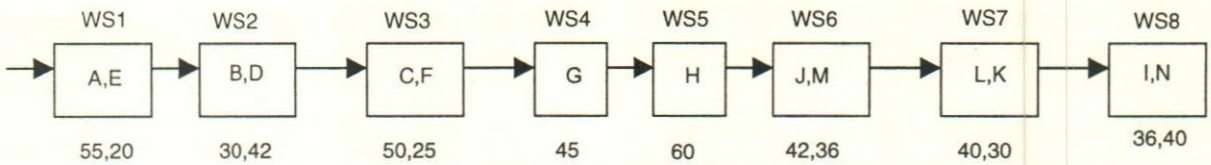

Fig. 2. Initial allocation of work elements

Step 6: Consider the bottleneck workstation (the work station with maximum total time, $T_{si}max$). Perform the following operations.

a) Interchange the elements of bottleneck workstations one by one with their independent elements.

b) Shift some of the elements to any other workstation satisfying (i) precedence requirements and (ii) the condition $T_{si} \leq T_c$

Step 7: Repeat step 6 till no further improvement is possible.

Application example

A sample problem [4] with 14 tasks has been chosen for study. The task codes, task time and Interdependency are shown in Table 1. The independent elements for each task have been identified from the precedence diagram (refer Fig. 1). Independency weightage (IW) has been computed for each task. They are shown in Table 2.

Allocation of tasks to workstations by CoM

Considering cycle time (T_c) as 85 seconds, the allocation of elements to various workstations is initiated. Initial allocation is shown in Fig. 2. This allocation results in WS6 as the bottleneck station, that decides the cycle which ($T_{si}max$) is 78 seconds. The interchange of possible elements based on IW is performed as follows:

Interchange J with I,K	As L,M depend on 'J', this is not recommended.
Interchange M with I	There will not be any improvement.
Interchange M with L	There will not be any improvement.
Interchange M with K	It leads to improved solution.

Table 2 (a): Modified allocation of work elements by CoM

Station	Task	Time (sec)	Time left in seconds	Indepedent elements (k_x)	Independency Weightage (IW)	Ready tasks
						A,E,F
1	A	55	21	E,F	100	E,F,B,C,D
	E	20	1	A,B,C,D,F	222	F,B,C,D
2	B	30	46	E,F,C,D,G	212	F,C,D
	D	42	4	E,F,B,C,G	212	F,C
3	C	50	26	E,F,B,D,G	212	F,G
	F	25	1	A,B,C,D,E	222	G
4	G	45	31	B,C,D	167	H
5	H	60	16	–	60	I,J,K
6	J	42	34	I,K	108	I,K,L,M
	K	30	4	I,J,L,M	184	I,L,M
7	L	40	36	I,M,K	142	I,M
	M	36	0	I,L,K	142	I
8	I	36	40	J,LM,K	184	N
	N	40	0	–	40	–

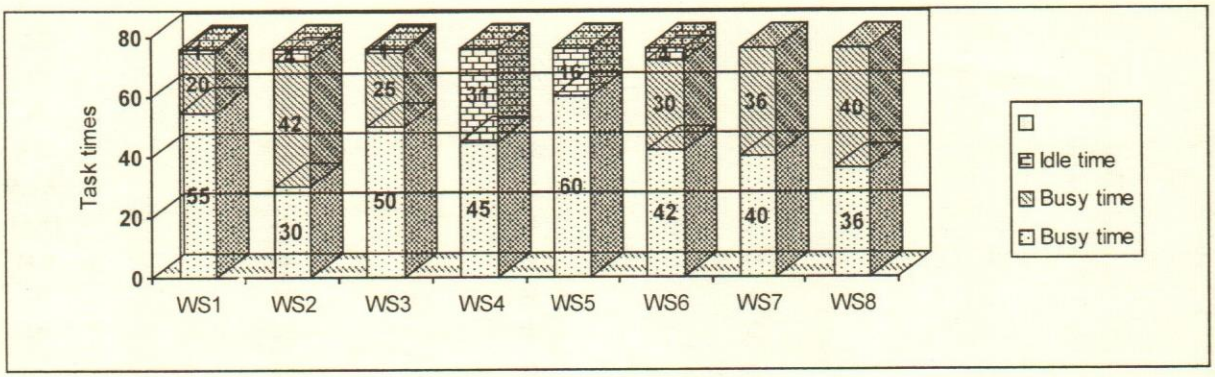

Fig. 3. Elemental allocation by CoM

Modified allocation of work elements and results are shown in Table 2 (a) and Table 2 (b). WS7 and WS8 resulted as bottleneck workstations with cycle time as 76 seconds. Any further modification of elemental interchange among the workstations does not improve the result. Thus, the optimised allocation by CoM resulted in cycle time of the line as 76 seconds.

Comparison of CoM and RPWT heuristic methods

Allocation of elements to various workstations by CoM resulted in maximum station time as 76 seconds and a balance delay of 9%. The better allocation also resulted in reduced idle time in most workstations while WS7 and WS8 are fully loaded. Results have been shown in Table 3.

Elemental allocation by best-selected heuristic i.e., RPWT, resulted in maximum station time as 82 seconds and balance delay of 16%. From Figures 3 and 4, it is evident that the idle time in most workstations by RPWT is more than that of CoM. Improved line efficiency, reduced station time by CoM, leads to higher production rate.

Table 2 (b): Results of modified allocation by CoM

Summary statistics		
Theoretical cycle time	84	Seconds
Actual cycle time T_{si}	76	Seconds
Time allocated $WS_a * T_{si}$	608	Seconds
Time needed (sum of task times)	551	Seconds
Idle time(allocated–needed)	57	Seconds
Efficiency(needed/allocated)	91	%
Balance delay (1-efficiency)	9	%
Min(theoretical) number of work stations	7	

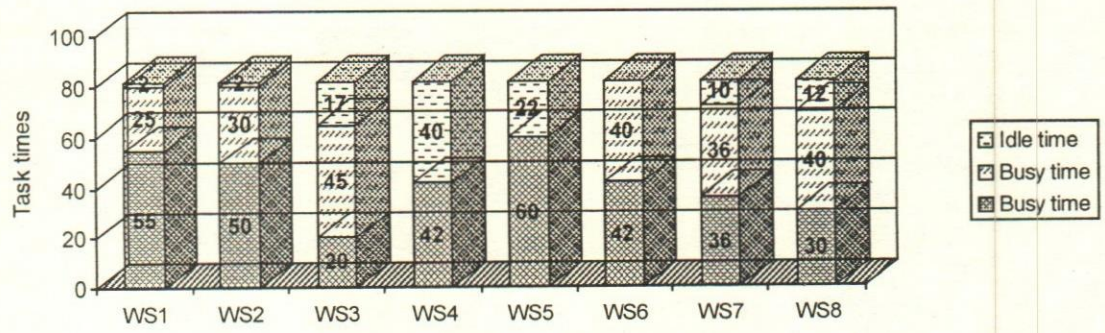

Fig. 4. Elemental allocation by RPWT

Table 3: Allocation of work elements by RPWT

Station	Task	Time (sec)	Time left in seconds	Ready tasks
				A,E,F
1	A	55	27	E,F,B,C,D
	F	25	2	E,B,C,D
2	C	50	32	E,B,D
	B	30	2	E,D
3	E	20	62	G,D
	G	45	17	D
4	D	42	40	H
5	H	60	22	I,J,K
6	J	42	40	I,K,L,M
	L	40	0	I,K,M
7	I	36	46	K.M
	M	36	10	K
8	K	30	52	N
	N	40	12	–
Summary statistics				
Theoretical cycle time	84			
Actual cycle time T_{si}	82	seconds		
Time allocated $WS_a * T_{si}$	656	seconds		
Time needed (sum of task times)	551	seconds		
Idle time (allocated-needed)	105	seconds		
Efficiency (needed/allocated)	84	%		
Balance delay (1-efficiency)	16	%		
Min. (theoretical) number of work stations	7			

Results And Disscussion

Figure 5 shows comparative results on line efficiency and production rate based on best-selected heuristics. Five problems have been used for comparative study. For selected maximum cycle time, CoM shows better line efficiency for problem 1 and 3. The difference is quite significant and it resulted mainly with interchanging the independent elements wherever possible.

The independent element concept is novel and systematic. It helps in interchanging elements in bottleneck workstations stepwise by decreasing the cycle time. Thus it also helps in choosing a particular value of cycle time, i.e., one can stop the process at any stage if one so desires. But in the case of LCR and RPWT this may not be possible. However, in the case of problems 2, 4 and 5, the efficiency obtained by CoM is comparable to RPWT. In all the cases, it is not significantly less than RPWT. However, it may be noticed that in case of prob-

Table 4: Comparison of performance measures of LCR, RPWT and CoM

Performance measure	Problem 1 n = 14 WS_{th} = 7 T_c = 85 sec			Problem 2 n = 24 WS_{th} = 8 Tc = 1.1min			Problem 3 n = 12 WS_{th} = 6 Tc = 18min			Problem 4 n = 10 WS_{th} = 6 Tc = 1.3min			Problem 5 n = 12 WS_{th} = 5 T_c = 1min		
	L	R	C	L	R	C	L	R	C	L	R	C	L	R	C
WS_a	8	8	8	9	8	8	6	6	6	6	5	6	5	5	5
T_{si} (max.)	85	82	76	1	1	1.02	18	18	17	1.3	1.3	1.1	1	0.92	0.93
$_b$ (%)	81	84	91	86	97	96	90	90	95	72	86	85	80	87	86
PR	42	43	47	60	60	58	3	3	3	46	46	54	60	65	64

Codes: L = LCR; R = RPWT; C = CoM

Legends:

WS_{th} : Number of theoretical work stations WS_a: Number of actual work stations

PR: Production rate/hour η_b: Line efficiency

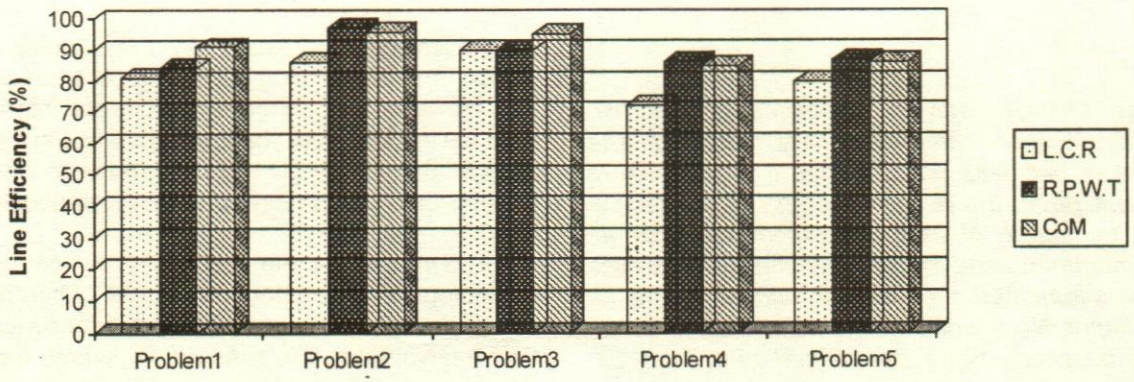

Fig. 5. Comprehensive Method vs LCR and RPWT

lem 4, the cycle time is least in the case of Comprehensive method and it is useful in increasing the production rate. In the case of sample problem (problem 1), the idle time is quite uniform when compared with RPWT (refer to Fig. 3 and 4) for all the workstations. It is quite distinguishable in the case of workstation number 4. For all the test problems, it has been noticed that the idle time is uniform in the case of the comprehensive method. Thus, the result indicates that Comprehensive method gives improved line efficiency with reduced idle time for most of the problems.

Conclusion

A comprehensive method of line balancing for single model assembly line was developed. Improved line efficiency is achieved in most of the cases while comparing with traditional heuristic methods such as L.C.R, and R.P.W.T. Performance measures such as line efficiency, balance delay, number of workstations, etc., have been compared for evaluation of the developed method. The task times are considered as less than the maximum station time, which leads to a "linear" line. The comparative study can be extended to different values of cycle times for each example problem. Mixed models considering paralleling concepts may also be worked on in the proposed method. The programme developed in C++ can be used for a general computerised approach to solve line-balancing problems.

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Feature

An Entropy Based Model for Innovation Diffusion

S. Suresh Kumar & L.S. Ganesh

Knowledge change, with its dynamics of theoretic shifts, has not been comprehensively modelled. The implication of business policy is that it is possible to determine, a priori, the relative success of the technique and the scope of its development. An entropic measure has been used for representing the dynamics typically as a truncated phenomenon with respect to the diffusion factor. Non linearities intrinsic to the information diffusion process are determined both by a diffusion coefficient (velocity parameter) and a "reintroduced" diffusion factor. The dynamics typically represents all routes to chaos for different values of the parameter.

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Survey of Some Important Models

A probabilistic Model of Innovation Processes

An invention is essentially the creation of a new device. An innovation is the first application of an invention. However, the two terms can be used interchangeably. Since the technical change takes place in a cumulative manner, there is a logic to it in as much as it is governed by a process of learning from past experience.

In symbols, let the probability of occurrence of a technological innovation during the differential dt be λdt, and p (n, t) the probability of n innovations in the time interval from 0 to t. As a very simple model incorporating the role of chance in the phenomenon under consideration, suppose that the process of innovation follows the Poisson distribution.

$$P(n, t) = \frac{(\lambda t)^n}{n!} e^{-\lambda t}, \; n = 0,1,2 \qquad ...(1)$$

The central features of the Poisson process are well known. In the preset context, they imply that

(1) The probability rate of the occurrence of innovations, n, is invariant in time.

(2) The chance of occurrence of an innovation is independent of whether previous innovations have occurred recently or not.

(3) In a very small time interval, no two innovations can occur simultaneously.

This is not to say that the innovations, in fact, occur in a completely random manner, as implied by the Poisson representation of the process. Rather, it is hoped that the detection of departure from randomness may shed light on the mechanism underlying the observed phenomenon.

Thus, the above model may be regarded as a convenient starting point from which to consider the number of innovations in successive periods of a given duration. Upon expressing n as a yearly rate of occurrence of innovations, we have t = 1 and can be written as

$$P(n) = \frac{(\lambda)^n}{n!} e^{-\lambda} \quad ...(2)$$

However, it may not be realistic to assume that the probability rate of occurrence of innovations remains constant in so far as the process of technological change is governed by causes of a cumulative nature. Instead, the parameter n is best regarded as a random variable itself with probability density p(n); the relevant formulation of the process is then given by

$$P(n) = \int_0^\infty \lambda^n \frac{e^{-\lambda}}{n!} f(\lambda)\, dt \quad ...(3)$$

The simplest frequency distribution that allows some variation in h is the Eulerian distribution.

$$f(\lambda) = (\alpha)^{-1} \beta^{-(\alpha+1)} \lambda^\alpha e^{-\lambda/\beta}, \beta > 0, \alpha > 1 \quad ...(4)$$

The chief merit of this distribution is its flexibility, since it has two adjustable parameters. By combining Eq (3) with (4), we obtain the negative binomial distribution.

The most attractive feature of the above model is that it makes possible a probabilistic formulation of the cumulative mechanism underlying the process of innovation. This is also justified by evidence from other fields. For example, two of the prominent empirical distributions to which the negative binomial model applies are (i) deaths in the case of population subject to a cumulatively fatal disease or toxin and (ii) purchases of a product under the influence of repetitive advertisements (Rogers, 1962). Thus, there is further justification for regarding the negative binomial as an appropriate model of the phenomena under consideration.

The Logistic Model

It is postulated that an individual firm's decision to adopt a new technique is dependent on the number of firms already using it. It can be shown that under some very simple assumptions, this hypothesis implies an s-shaped curve of diffusion over the course of time. For example, suppose that the rate of diffusion of an innovation at any given point in time is proportional to the existing level of diffusion and to the gap between its instantaneous and ultimate levels of use. In symbols,

$$\frac{dN}{dt} = r N (K-N) \quad ...(5)$$

Where N denotes some measure of diffusion level, K the saturation (or equilibrium) level, t the time, and r the constant of proportionality. The solution of this differential equation is the well-known logistic function.

$$N = \frac{K}{1+ae^{-bt}}, \; b = rK \quad ...(6)$$

Where a is a constant depending on the initial conditions, and b is the "rate-of-growth" parameter. It can be easily shown that the logistic curve is a symmetrical S-shaped curve. According to the available empirical evidence (Griliches, 1957, Mansfield, 1961), certain cases of diffusion process can be adequately described in terms of the logistic type of growth.

Frequently, however, the data on the diffusion of innovations contain an element of skewness. In the circumstances, the use of the logistic function is clearly inappropriate. Rather we must employ some other asymmetrical S-shaped curves. Examples of these are the Gompertz function, and the cumulative log-normal distribution function. The present state of our knowledge in this are woefully inadequate to provide a theoretical basis for specifying the functional form of the diffusion process.

The data on the diffusion of innovations contain an element of skewness.

Conversely, the adoption of an innovation may be thwarted for want of necessary changes in its design and performance. Thus, the failure to reduce the level of vibrations and noise associated with the combination of propeller and gas turbine appears to have been the root cause of the success of the turbojet over the turboprop airliner in the 1940s; similarly, the current use of the tractor for a wide variety of operations not only in agriculture but also in industry owes a great deal to numerous changes in the characteristics of its design. These things also illustrate the inherent dynamics and paradigm shift of basic ideas of a science diffusion process (Jensen, 1982).

The specific examples cited above are illustrative of two fundamental features of diffusion processes. First, an innovation seldom remains unchanged during the course of its adoption. In many instances, changes in the design and performance characteristics of an in-

novation are a prerequisite to its adoption. In yet other instances, changes in an innovation make possible new applications, thereby facilitating its adoption beyond the originally conceived scope of its application. Thus, diffusion of a technology is characterised by changes of both qualitative and quantitative nature.

Second, it is evident that the adoption of a new technique is often related to the nature and significance of some comparable older technique in use. The diffusion of an innovation does not take place in isolation. Rather, it is very much a matter of actual substitution of a new technique for the old. In light of these considerations, it is easy to see that the diffusion of an innovation is expected to follow an S-shaped pattern of growth.

A technology can rarely perform in a flawless manner from its very birth. It is, therefore, to be expected that the rate of adoption of the innovation rapidly picks up as its performance is shown to be superior to the existing techniques. Finally, the growth in the use of a technology may be retarded in so far as there is a limit to improvement in its performance.

The above considerations suggest what may be called a "diffusion via learning" hypothesis of technological change. The diffusion of a technique is conditional upon learning in its adoption and development. Further, the diffusion curves of both the new and old techniques are likely to follow some S-shaped patterns of growth. Last but not the least, these patterns themselves are expected to be interrelated (Bass, 1969).

Two Models of Technological Substitution

The first model focuses on the temporal aspects of the phenomenon. It was originally presented by Fisher and Pry (1971), who also gave a number of instances of its applications. The second model on the spatial aspects of the phenomenon was originally developed by biologists in their study of morphological changes in organisms. It is shown that these two formerly disparate models are in fact complementary to each other (Dosi, 90).

Other Important Models

A number of technological substitution models of innovation diffusion have been proposed by various researches in order to study its time-dependent aspects (and possibly the space–dependent aspects) (Rogers, 1983). The models differ in their respective rates of df/dt increase. In some models, df/dt may increase very quickly at the beginning, reach its peak at the point of inflection, and then decrease slowly to fall to zero. In other models, the approach to the point of inflection may be relatively slow. This means that models may differ in the fraction of adopters f at the point of inflection.

A number of technological substitution models of innovation diffusion have been proposed in order to study its time-dependent aspects.

The early successful checks on S-shaped diffusion models were obtained by Mansfield by fitting the models with historical substitutions of rail roads, coal, steel and breweries. Blackman applied the model to study innovation dynamics in the aircraft jet engine market and in electric utility and automotive sectors. The universal growth curve developed by Floyd attempts to explain growth towards an upper limit on the basis of efforts expended. His model was well fitted to aircraft speed, and was found suitable for forecasting the progress of a single technical approach. The growth models seem valuable for the effective management of technology. Bhalla presents these curves as a projective technique for predicting technology and its expected rate of application of problems, and comparing the performance of one technology with another.

Fisher-Pry gave a substitution model of technological change which was based on the following assumptions (i) if the growth of an innovation has progressed to a point measured as a small percentage, it will proceed to completion, (ii) the fractional rate of fractional substitution of new for old is proportional to the remaining amount of old left to be substituted; and (iii) many technological advances can be considered as competitive substitutions of one method satisfying a need for another. Blackman modified the Fisher-Pry model by considering an upper limit of the share that the new innovation can capture in the long run. In the Fisher-Pry model, this upper limit is taken to be 100% substitution.

The following equation can serve as a basis for describing the models discussed above.

$$\frac{df}{dt} = qf\,(F-f) \qquad \ldots(7)$$

Where f is the fraction of the potential adopters representing those who have adopted the innovation up until time t, F is the upper limit of the market share, and q is a parameter which can be interpreted as the coefficient of imitation or internal influence, or interaction, between the adopters and the potential adopters.

Floyd's model represents an attempt to explain growth towards an upper limit on the basis of a effect expended, and is given by

$$\frac{df}{dt} = cf\,(F-f)^2/(F-fc) \qquad ...(8)$$

Where fc is the functional capability of the competitive technology and c is a constant (Floyd, 1968).

Sharif and Kabir suggest a generalised model (Sharif, 1976).

$$\frac{df}{dt} = qf\,(F-f)^2/[F\,(F-f\,(1-\sigma))] \qquad ...(9)$$

Where d is a dimensionless factor lying between 0 and 1.

It can be observed that, for d = 0, F = 1 we have the Fisher-Pry model; and for d = 1, we have the Floyd model. The parameter, d, was considered a function of data scatterness, data extent, market share at the time of the forecast, and effective life span (i.e., the estimated time required for f to go from 0.1 F to 0.9 F).

In the relevant literature, five classes of adopters have been categorized as innovators, early adopters, early majority, late majority and laggards. Innovators are those individuals who decide to adopt an innovation independent of decisions made by other individuals in a particular social system (although innovators do interact with other innovators); their decision may be largely affected by mass-media channels. Bass merged the four remaining categories into one category of imitators. Imitators, unlike innovators, are influenced by the decision of other members of the social system. The Bass model is

$$\frac{df}{dt} = (pF + qf)\,(1-f/F) \qquad ...(10)$$

Where parameter p is called the coefficient of innovation and q, as before, is the coefficient of imitation.

Bass tested his model empirically against data for 11 consumer durables. This model has been widely adopted, extended and employed for forecasting (Bass, 1969).

According to Bundegaard-Nielson (1976), late adopters may adopt more quickly than earlier ones since they are in a better position to assess the new technology. Easingwood et. al gave a non-symmetric responding logistic (NSRL) model by introducing a time varying coefficient of imitation d (Easingwood et. al, 1981).

This model has been compared with the Fisher-Pry and the Sharif Kabir models, and its effectiveness has been shown by using time series data for four medical innovations, namely the CT head scanner, the CT body scanner, Ultra-sound and Mammography, collected from a survey of 206 hospitals (Sharif and Kabir, 1976).

Easignwood et. al, also incorporated a non-uniform influence (BUI) factor in the Bass model, and gave the following.

$$\frac{df}{dt} = (p + q)\,(f/F)^{\delta}\,(F-f) \qquad ...(11)$$

This model has been examined over data for five consumer durables, these being black and white televisions, colour televisions, cloths dryers, room air conditioners, and dish washers. It was shown that this model provides a better fit than the Sharif-Kabir or the Bass models.

Shiadas introduced a parameter g, which represents a sum of positive and negative influence of non-adopters or potential adopters. The model, called the generalized model, is as follows: (Shiadas, 1986)

$$\frac{df}{dt} = q\,(f+ g)\,(F-f)/(F+ g) \qquad ...(12)$$

The equation reduces to the Bass model by manipulating the parameters. Kumar and Kumar have proposed two models (Kumar and Kumar, 1992).

The KKKI model has the advantage of also accounting for external influences. The KKII model takes into account the effect of the fact that the "yet to adopt" population has a varying degree of technological background which has an impact.

The various substitution models discussed above differ mainly on the basis of three important characteristics:

(i) The number of parameters and their ranges;

(ii) The location of their point of inflection; and

(iii) The symmetric or non symmetric behaviour about the point of inflection.

Theoretical Base of Proposed Model

Science Diffusion Vs Technology Diffusion

A number of innovations of far-reaching significance are demonstrably attributable to the intermingling of

science and technology, as, for example, in the case of the chemical and electronic industries. However, the course of technological development depends, to some extent, on accumulated experience of a practical nature. So, the traffic between science and technology is typically subject to the rules of a two-way street (Ray, 1989).

Technological trajectories result from an interaction of the knowledge production and market development sectors mediated through the agency of an entrepreneur. There is some justification to assume that knowledge production and market developments keep back, in view of the centrality of information in our societies. The operation of the knowledge production system is self referential, in that they evidence an internal processing of history; technology represents a cumulative learning process and a certain high path-dependency and critical mass in its diffusion process, as evidenced. Knowledge-production is more reflexive in nature, and involves a second order feed back (Sounder, 1987).

Main Characteristic Required for Science Diffusion Model

It is observed that the science diffusion process is non-linear. Apart from this non-linearity, two other main characteristics need special discussion. They are the paradigm shift and chaotic nature of the science diffusion process (Suresh Kumar et. al, 1993).

The science diffusion process is non-linear.

The paradigm shift

As knowledge diffusion reaches a certain level, there occurs a theoretic shift in basic knowledge characterising its development process. However, knowledge change, with its dynamics of theoretic shift, has not been comprehensively modelled as such. It is observed that as existing theories diffuse wider into society, new theories are formulated. That is, as theory gets widely accepted, intrinsic processes are set in motion, which result in shifts in the theoretic base, characterising new directions in knowledge change. The new theory or paradigm starts diffusing afresh, only to get truncated again as diffusion reaches a certain level (Sahal, 1981).

Since most of the available models are related to technological diffusion, these models look into the cumulative nature of the changes. In other words. these models do not take into account, the paradigm shift phenomena of the science diffusion process explicitly. In our model, a 'mod' function and logarithmic interaction are used to reflect this paradigm shift phenomenon, and also to introduce non-linearities, taking into account the stochasticity and the intensities inherent in the interaction. The knowledge diffusion process proceeds to a limit whereby it simulates new knowledge creation through a non-linear process among the diffusing population. Non linearities, intrinsic to the science diffusion process, can be determined by appropriate choice of the parameter (intensity of diffusion) over the time horizon.

Measure of Entropy as a Modelling Criteria

Most existing models have been developed by adopting the conventional approach of modelling, which consists of understanding the nature of the process, characterising the system, defining its variables, formulating their relationships in the form of mathematical equations, and eventually validating that model by fitting a set of data to it. But measures of entropy in the field of information theory can be effectively used for developing science diffusion models (Kapur, 1992).

Komogorov Entropy

The thermodynamic entropy S measures the disorder in a given system, a simple examples, for a system where S increases, is that of gas molecules that are initially confined to one half of a box, but are then suddenly allowed to fill the whole container. The disorder is coupled with an increase of our ignorance about the state of the system (before the confinement was lifted, we knew more about the positions of the molecules).

More precisely, the entropy S, can be expressed as

$$S \alpha - \sum_i pi \log p_I \qquad ...(13)$$

Where [pi], the probability of finding the system in state [i], measures, according to Shannon et al, (1949), the information needed to located the system in a certain state i*, that is, S is a measure of our ignorance about the system.

The example from statistical mechanics shows that disorder is essentially a concept from information theory. It is, therefore, not too surprising that the kolmogorov entropy K, which measures "how chaotic a dynamical system is", can also be defined by

Shannon's formula in such a way that K becomes proportional to the rate at which information about the state of the dynamical system is lost in the course of time.

For one dimensional maps, K is just the positive Lyapunov exponent. In higher dimensional systems, we lose information about the system because the cell in it was previously located and spreads over new cells in phase space at a rate which is determined by the positive Lyapunov exponents. It is, therefore, plausible that the rate K at which information about the system is lost is equal to the (averaged) sum of positive Lyapunov exponents.

The Proposed Model

Differential equations describe processes that change smoothly over time, but differential equations are hard to compute. Simple equations 'difference equations'—can be used for processes that jump from state to state. Changes year to year are often more important than changes on a continuum. A year-by-year facsimile produces no more than a shadow of a system, but in many real applications the shadow gives all the information a scientist needs.

This process of functional iteration requires a feedback loop, each year's output serving as the next year's input. Feedback can get out of hand, as it does when sound from a loud speaker feeds back through a microphone and is rapidly amplified to an unbearable shriek. Or feed back can produce stability, as a thermostat does in regulating the temperature of a house, any temperature above a fixed point leads to cooling, and any temperature below it leads to heating.

The proposed model considered these two important aspects. An entropy measure has been used for representing the dynamics of science diffusion. Concave functions are used as the basis for developing some well known entropy measures. The same function can be used in generating the science diffusion model. Shannon has given the following measure of entropy for probability distribution.

$$P = (P1, P2, \ldots, Pn) \qquad \ldots(14)$$

$$S(p) = \sum_{i=1}^{n} \Psi(P1)$$

concave [0, 1] and vanished both when x = 0 and when x = 1. Later, other non-negative concave functions which vanished at x = 0 and x = 1 were used to develop other measures of one or more parameters.

Consider the following concave function

$$\Psi(x) = -x\ln x + 1/a\,(1=ax)\ln(1=ax) - x/a\,(1+a)\,\text{in}\,(1=a)a \geq -1 \qquad \ldots(16)$$

This was earlier used to derive Kapur's measure of entropy. The model is given by

$$\frac{1}{c}\frac{df}{dt} = -f\ln f + \frac{1}{a}(1+af)\ln(11=af) - \frac{1}{a}(1+a)\,\text{in}(1+a)\,f \qquad \ldots(17)$$

Substituting a = –1, we can reduce to

$$\frac{1}{c}\frac{df}{dt} = -\{f\ln(f) + (1-f)\ln(1-f)\} \qquad \ldots(18)$$

Where c is a diffusion coefficient (velocity parameter) and f is the fraction of adopters till time t.

c is the internal variable which evolves from the dynamics of the diffusion process. If it can be controllable through say, government funding for R&D, increased publications, etc., then we can easily reach the stable region of the science diffusion process, and a new technology can emerge. This is related to the other scope of this project.

One important problem is the measurement of the fraction of adopters f. The population can be taken as the total number of the scientists working all over the world in a particular field. The fraction of this population that agrees to a particular theory can be taken as f.

Non linearities intrinsic to the science diffusion process are determined both by a diffusion coefficient (velocity parameter) and a "re-introduced" diffusion factor. A "mod" function is used to reflect the paradigm shift of the science diffusion process and also to introduce non linearities, taking into account the stochasticity and the intensities inherent in the interaction. This model makes use of a concave function based on information theoretic entropy measure representing non-algebraic functions. The diffusion mechanism represents the dynamics typically as a truncated phenomenon, which respects the diffusion factor. The proposed model representing a logarithmic interaction allows for the rep-

Non linearities intrinsic to the science diffusion process are determined both by a diffusion coefficient and a "re-introduced" diffusion factor.

Behaviour of the Proposed Model

Time series

Traditionally, the changing values of any one variable with respect to time intervals is displayed in a so-called time series. Here, the changing value of fraction of adopters f, for a specific value of velocity factor c is displayed. Equal time intervals are taken on the horizontal axis, and corresponding values of fraction of adopters are taken on the vertical axis. A number of figures can be obtained for different values of parameter c.

The value of parameter c changed from 0.1 to 3.25 at equal intervals of 0.001. If the parameter value is in between 1.442 and 1.788, the model gives a steady state. Similarly, in the range of c between 2.884 and 3.106, the model again gives a steady state.

If the value of c is in between 1.789 and 1.911, the model gives period two phenomena. If the range of c is between 3.017 and 3.2, then also it gives period two characteristics.

Robert May and his colleagues used a "bifurcation diagram" to assemble all such information into a single picture. It is a diagram of attractors. The diagram shows how changes in one parameter—in this case, the velocity factor—would change the ultimate behaviour of a simple system (May, 1976).

As the parameters rise, so does the equilibrium level of the fraction of adopters. Then, as the parameter rises further, the equilibrium splits in two, just as turning up the heat in convecting fluid causes an instability to set in, the fraction of adopter begins to alternate between two different levels. The splitting, or bifurcations, come faster and faster. They the system turns chaotic, and the fraction of adopters visits infinitely many different values. Yet in the middle of this complexity, stable cycles suddenly return. Even though the parameter is rising, meaning that the non-linearity is driving the systems harder [illegible] will suddenly appear with a [illegible] 3 or 7. The tem will also display regular cycles of every other length, as well, as completely chaotic cycles.

In dissipative systems, strange attractors are formed from the compromise of two opposite trends; dissipation plays a global stabilizing role, by contracting the phase space volume, while local orbital instability forces initially neighbouring orbits to separate exponentially. Phase volume contraction does not imply shrinking of nearby trajectories in all directions. There may be other directions along which the distances between these orbits stretch all the time. Therefore, a more detailed study of the strange attractor inevitably involves the behaviour of a bunch of orbits instead of a single orbit.

Adjacent points become separated under the action of map.

$$X^{n+1} = f(X_n) \qquad \ldots(19)$$

Which lead to chaotic motion. The Lyapuov exponent $l(X_0)$ measures this exponential separation.

This means that $e^{l}(X_0)$ is the average after which the distance between closely adjacent points becomes stretched after one iteration.

The Lyapurnov exponent also measures the average loss of information (about the position of a point [0, 1] after one iteration).

The Lyapunov exponents in a system provided a way of measuring the conflicting effects of stretching, contracting, and folding in the phase space of an attractor. They gave a picture of all the properties of a system that lead to stability or instability. An exponent greater than zero meant stretching—nearby points would separate. An exponent smaller than zero meant contraction. For a fixed point attractor, all the Lyapunov exponents were negative, since the direction of pull was inward towards the final steady state. An attractor in the form of periodic orbit had one exponent of exactly zero and other exponents that were negative. A strange attractor, it turned out, had to have at least one positive Laypunov exponent. This proposed model also exhibits the properties mentioned above, and the values of average Lyapunov exponent (L) for c changing from 1.5 to 2.4 are tabulated in a table.

Table: Average Lyapunov exponent

Validation of the Model

All innovation diffusion processes contain a non-linear process before and after the logistic growth. Thus, non linear processes are responsible for the chaos like states. This inherent nonlinear processes are also responsible for the paradigm shift of basic knowledge. Technology emerges when the diffusion process attains stability. Since technology is a cumulative learning process, it can be shown by a logistic S-curve. If we incorporate the non-linearities at the beginning and end of this logistic S-curve, tne process should be as shown in Fig. 1.

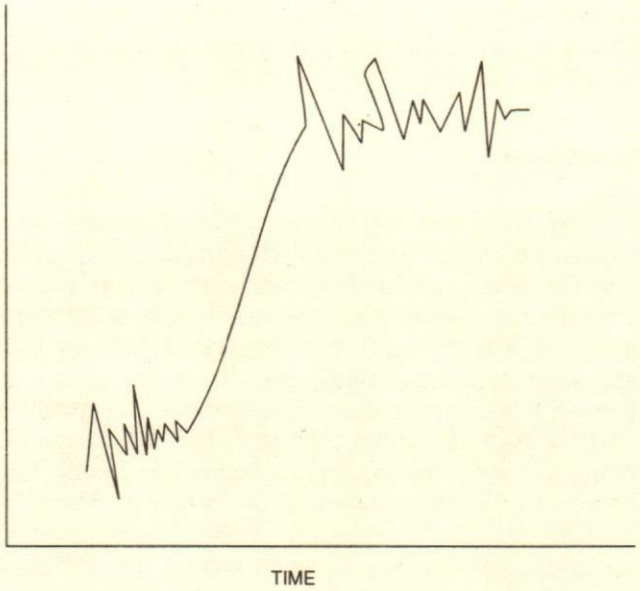

Fig. 1. Chaos Like States at the Beginning and End of the Logistic S Curve

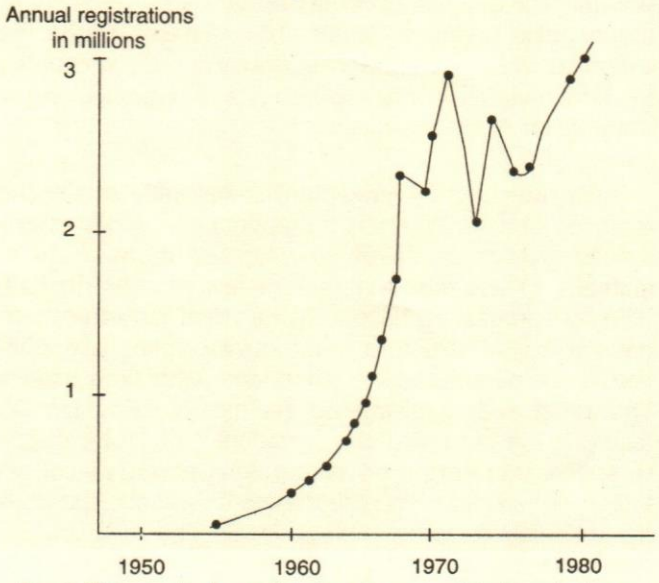

Fig. 2. This graph shows data for new car registrations in Japan as reported by Marchetti

This is evidenced from the actual data also. Some of them are shown in figures.

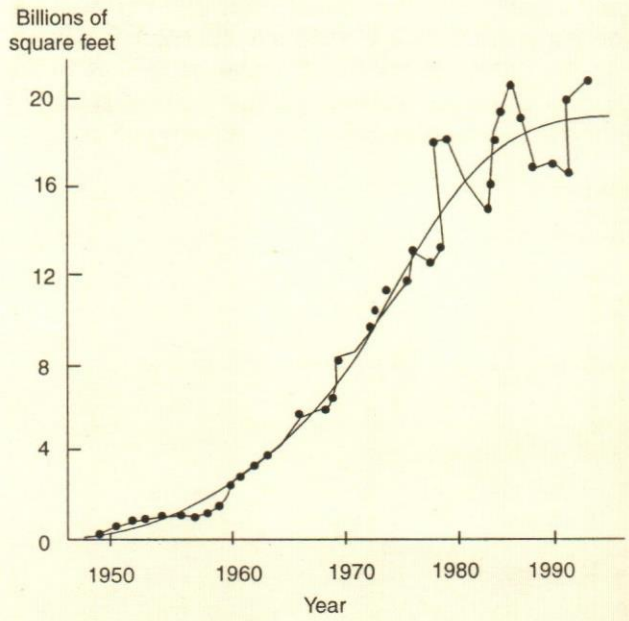

Fig. 3. The annual plywood sales in the United States

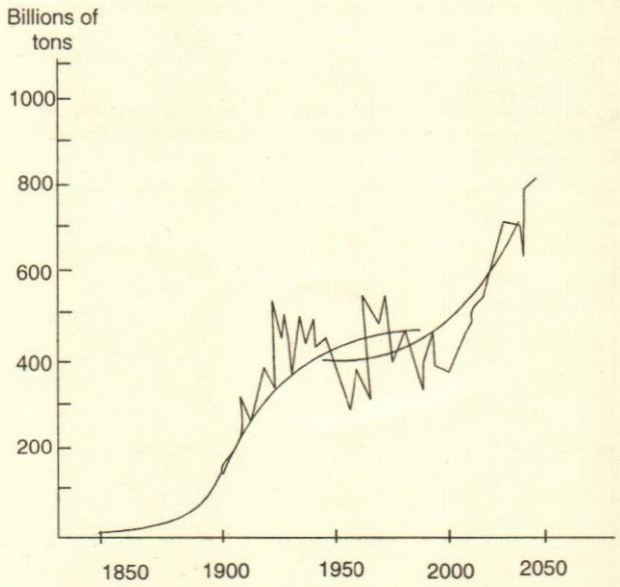

Fig. 4. Annual production of bituminous coal in the United States. The S curves shown are logistic fits to the data for the respective historical periods. The Interim period shows large fluctuations of a chaotic nature.

Both the processes shown follow a logistic growth developing significant random fluctuations as the ceiling is approached. Chaos provides a mechanism for explaining these fluctuation. The non-linear process at the beginning can be considered as a trial period, during which survival is at stake and major readjustments may be undertaken. This is evidenced by industrial products that are often repositioned price wise and/or perfor-

mance wise, shortly after launching. The logistic growth is due to a surge in sales after product introduction. The large oscillations in the annual production of coal between the years 1920 and 1960 may be seen as belonging to the ceiling of the first S curve as well as to the beginning of the second one. The generalised picture is one of alternating states of logistic growth and chaos.

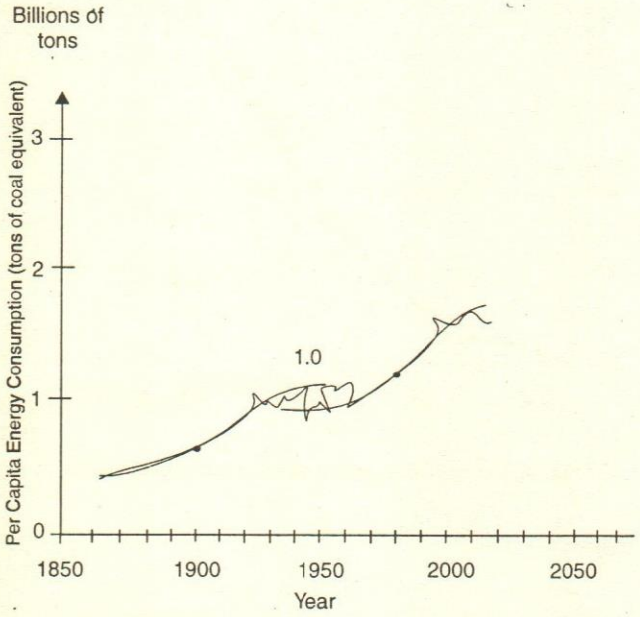

Fig. 5. The per capita annual energy consumption worldwide. The graph published by Ausubel at shows data, logistic fits.

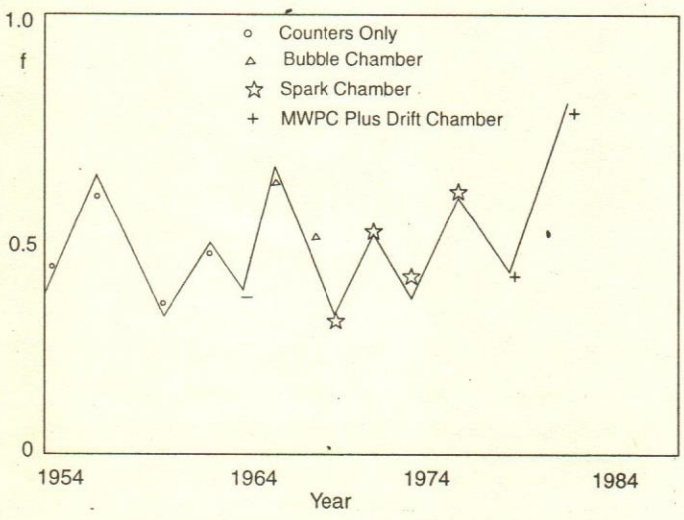

Fig. 6. Use of Four Different Experimental Techniques

A well-established s-curve will point to the time when chaotic oscillations should be expected: it is when the ceiling is being approached. Similarly the chaos will reveal when the next growth phase will start: it is when the next steady state is reached. One has to also take into account other considerations particular to each case to locate the next growth phase.

The suggested model is a flexible model, and can be used for modelling almost all types of technological diffusion processes and science diffusion processes, especially in high science areas. Here the velocity factor c is a function of time and system specific. To find out different functions for C with respect to different situations and thus modeling the situation is related to the further scope of this project.

For the time being, consider the data given by Sanford T.W.L. (1983), in his paper "Trends in Experimental High–Energy Physics". The time series for c = 1.1 from the proposed model is best fitted with the graph of the diffusion of four categories of experimental techniques, namely counters-only, bubble chamber, spark chamber and Multi wire Proportional chamber (MWPC) plus drift chamber.

Conclusion

The main theories of technological innovation includes the role of accumulated experience, specialization via scale, demand for technology and induced innovations. Despite these general issues of concepts, methods and theory, many examples of curve fitting are seen in diffusion literature. There are simple examples taken from biology: for instance the growth to limits of bacteria. There are the Fisher-Pry competition models. These are logistic functions, Gompertz functions and modified exponential functions. There are multiple substitution models. There is no resolution about the applicability of each model, other than to say, use a model that makes sense and to enjoy the fact that some simple relationships are deep and important. The sight of good fits of data and the scent of theory raise hopes of predictability. These include the extent to which natural and social systems are chaotic, tending towards certain forms of self-organisation, or more strongly deterministic.

The question of predictability naturally raises the question of time. Whereas transportation infrastructures spread over intervals of 50 years or more, clothing fashions diffuse world wide in a few months. In fact, diffusion processes have a hierarchical structure, perhaps a fractal structure. Alternatively, there is a continuum of parameters on short and long time scales. The most widely discussed feature of temporal diffusion is the bunching of innovations to turn from time to space, there are lively discussions about spatial diffusion. When diffusion researchers talk about space, is the meaning of space metaphorical? The meaning appears to go beyond traditional geographical coordinates. Technology is dissolving the role of contiguity (Baptisata, 2001).

Another point is application of diffusion for policy, especially in firms and the national economy. Judgements here are closely related to views on the predictability question. Application of diffusion methods is itself diffusion and adoption. It might be called the diffusion of diffusion. At a conceptual level, there may be useful notions for policy and applications apart from specific predictions. Diffusion can be applied for strategic business decisions also. Whether it is a question of diversification or integration, or whether it is a question of merger to takeover, nowadays, diffusion analyses find a place in it (Stanford, 1986).

Even when we observed a cumulative learning process or incremental change or scale variation at the macro level, there is a micro level turbulent process due to the search processes and the characteristic shifts which we have already discussed. This work mainly concentrated on this micro level turbulent process. This can be seen at the beginning and end of even the logistic growth process for technological diffusion. The theory is a very flexible one, and can be used for modelling almost all types of technological diffusion processes and science diffusion processes, especially in high science areas. The data given by Sanford. T.W.L. (1983) is his paper "Trends in Experimental High-energy Physics" is taken and the proposed model is best fitted to this data.

The suggested model contains a constant c known as diffusion coefficient (velocity parameter). This is the internal variable, which evolves from the dynamics of the diffusion process. If it can be controllable through, say, Government funding for R&D, increased publications etc, then we can reach the stable region of the science diffusion process and new technology can emerge.

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Feature

Performance of Newly Disinvested Central Public Sector Enterprises

C. Vanlalramsanga

This paper compares the pre-and post-divestiture performance of the 15 central public sector enterprises in India that have experienced partial privatization through the disinvestment programme of the government of India whose equity shares of 10 per cent or more were disinvested during 1991-92. The study documents a significant increase in the gross profit margin after divestiture while return on investment is on a decline, but the decline is statistically insignificant. The study also finds an insignificant increase in the debt-equity ratio after divestiture. Liquidity or current ratio also record a significant increase after the divestiture period, while capital turnover is on the decline, and the decline in capital turnover after divestiture is statistically significant.

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Privatization has been a worldwide phenomenon since the last two decades, and it has been adopted with different forms in different countries. A conspicuous wave of privatization, as an instrument of greater economic prosperity, is sweeping across global economies, enfolding the developed countries, the transitional economies and the less developed world as well. In fact, privatization or transfer of public sector enterprises to private ownership has been one of the most significant political decisions across the globe during the last two decades.

Given the attention the press has shown to the global movement towards privatization of state owned enterprises, many enthusiasts of privatization seem to conclude and believe that a shift from public to private ownership will automatically make for improved performance. However, empirical evidence of various countries on privatization not necessarily lends support to such a strong and simplistic belief. The empirical evidence on the impact of privatization seems to produce mixed results across countries, especially in the less developed countries. And these results act as a warning against generalization about the impact of privatization (Ram Mohan, 2001). This fact calls for a separate empirical study for a country as to whether disinvestments improved performance of the disinvested public enterprises.

The main objective of this paper is to study the financial and operational performance of newly disinvested central public sector enterprises (CPSEs) in India by comparing financial ratios of these CPSEs before and after divestiture. There are, to date, not many studies, covering assessment of disinvestment programme in India.

Disinvestment vis-à-vis privatization

Privatization will be defined and understood in this paper, for the sake of simplicity, as the deliberate sale of

public sector enterprises or assets to private economic agents by the government. On the other hand, disinvestments are defined as sale of parts of the equity shares held by the government to private investors. The disinvestment process, therefore, leads to dilution of ownership only, and not necessarily to transfer of full ownership. Therefore, disinvestments come to be known as 'partial privatization'. The extent of disinvestments, however, would determine the degree of dilution of ownership, and consequently, the extend of control that could be exercised by the government on the disinvested public sector enterprises. Notwithstanding the above differences between the two terms, the two terms i.e. privatization and disinvestments, will be used interchangeably in this paper, mainly because the objectives of privatization and disinvestments are broadly similar.

Public Sector Enterprises in India

The origin and growth of public sector enterprises were the result of the ideological climate that prevailed in the country after independence in which public ownership and socialist principles were held in high esteem. It was felt that public intervention offered a viable model for the simultaneous pursuit of social objectives and economic development under state hegemony (Raghavulu, 1997). Thus, the public sector in India assumed great significance as an important instrument of growth with social objectives, and it was considered as the power engine of economic development under state hegemony (Raghavulu, 1997). Thus, the public sector in India assumed great significance as an important instrument of growth with social objectives, and it was considered as the power engine of economic development. It attained commanding heights in the economy during the last five decades or so, and thus occupy a pivotal role in the planned economic development of the country, with its vast and diverse coverage of economic activities in the country.

Public intervention offered a viable model for the simultaneous pursuit of social objectives and economic development.

Public sector policy in India has been guided by the Industrial Policy Resolution of 1956, which assigned the public sector a strategic role in the economy (Dhaneja and Sastry, 2002). Major objectives described in the policy resolution are: to help in the rapid economic growth and industrialization of the country and create the necessary infrastructure for economic development; to earn return on investment and thus generate resources for development; to promote redistribution of income and wealth; to create employment opportunities; to promote balanced regional development; to assist the development of small scale and ancillary industries, and to promote import substitutes, save and earn foreign exchange for the economy, etc.

Massive investments have been made in the public sector to help attain 'commanding heights' in the development of the economy during the last fifty years, and the central public enterprises have witnessed a phenomenal growth during the period. Public Sector was increased from five units with an investment of Rs 30 crores in 1950 to 234 units involving an investment of Rs 274,114 crores in 2001 (Department of Public Enterprise, Government of India).

However, the involvement of the public sector in almost any kind of economic activity has come in for sharp criticism in recent years due to their low productivity, high costs and dismal return on investment. It is argued that private enterprises constantly strive to minimise costs in order to maximise profits, while public sector enterprises are not cost-conscious. And the delays in the completion of projects in the public sector enterprises also contribute substantially to increase costs. Besides, most of the public sector enterprises in India are overstaffed, resulting in a low level of labour productivity, which in turn has led to a steep rise in the cost of production. As on 31.3.2000, there were 232 operating central public enterprises, of which loss making central public enterprises were 106 (Department of Public Enterprises, Government of India).

Rationale for Disinvestments and Divestiture Experience

Within a coherent policy framework, divestiture of public enterprises or privatisation should be one element in a set of complementary actions designed to achieve both socio-political and economic objectives (Hatchette and Ludas, 1993) mainly to: reduce the administrative burden on the state bureaucracy, raise revenue for the central exchequer, improve an enterprise's profitability, enhance efficiency, create popular capitalism and develop new sources of income, etc.

Many of the theoretical arguments for privatisation are based on the premise that the harmful possible effects of state intervention have a greater impact under state ownership than under state regulation.

Apart form these, many economists also fear that the dominant role played by central public sector

enterprises in India may 'crowd-out' private investment in the economy. They maintain the view that public enterprises should be confined to essential functions and activities, which the private sector cannot or will not perform.

Besides, restructuring of loss making central public enterprises is of national significance and is a relatively difficult exercise. They are a drain of national resources and require budgetary support every year. The new Industrial Policy 1991 and pronouncement of divestiture of selected central public sector enterprises in India were revolutionary moves.

The new Industrial Policy 1991 and pronouncement of divestiture of selected central public sector enterprises in India were revolutionary moves.

The Ministry of Disinvestments came out with the rationale for disinvestments of central public sector enterprises in India as follows, "because of the current revenue expenditure on items such as interest payments, wages and salaries of Government employees and subsidiaries, the Government is left with hardly any surplus for capital expenditure on social and physical infrastructure. Whereas the Government should be spending on basic education, primary health and family welfare, huge amounts of resources are blocked in several non-strategic sectors such as hotels, trading companies, consultancy companies, textile companies, chemical and pharmaceutical companies, consumer goods, companies, etc. Not only this—the continued existence of the PSEs is forcing the Government to commit further resources for the sustenance of many non-viable PSEs. The Government continues to expose the taxpayers' money to risk, which it can readily avoid. To top it all, there is a huge amount of debt overhang, which needs to be serviced and reduced before money is available to invest in infrastructure, This makes disinvestments of the Government stake in the PSEs absolutely imperative."

The primary objectives of the disinvestments programme in India, as stated by the Ministry of Disinvestments, are: Releasing the large amount of public resources locked up in non-strategic PSEs for redeployment in areas that are much higher on the social priority, such as, basic health, family welfare, primary education and social and essential infrastructure; stemming further outflow of these scarce public resources for sustaining the unviable non-strategic PSEs; reducing the public debt that is threatening to assume unmanageable proportions; transferring the commercial risk, to which the taxpayers' money locked up in the public sector is exposed, to the private sector wherever the private sector is willing and able to step in—the money that is deployed in the PSEs is really public money and is exposed to an entirely avoidable and needless risk, in most cases; releasing other tangible and intangible resources, such as, large manpower currently locked up in managing the PSEs, and their time and energy for redeployment in high priority social sectors that are short of such resources.

On achieving these objectives, the government expects to derive the following benefits in the economy; disinvestments would expose the privatised companies to market discipline, thereby forcing them to become more efficient and survive on their own financial and economic strength or cease. They would be able to respond to the market forces much faster and cater to their business needs in a more professional manner. It would also free the PSEs from Government control, and corporate governance can be introduced in the privatised companies; disinvestments would result in wider distribution of wealth through offering of shares of privatised companies to small investors and employees; disinvestments would have a beneficial effect on the capital market; the increase in floating stock would give the market more depth and liquidity, give investors easier exit options, help in establishing more accurate benchmarks for valuation and pricing, and facilitate raising of funds by the privatised companies for their projects or expansion, in the future. Opening up the public sector to appropriate private investment would increase economic activity and have an overall beneficial effect on the economy, employment and tax revenues in the medium to long term; and in many areas, e.g., the telecom sector. The end of public sector monopoly would bring relief to consumers by way of more choices, and cheaper and better quality of products and services—as has already started happening.

Disinvestments in public sector enterprises was first done in India during the year 1991-92 on selected public enterprises with good track records by offering a part of their equity, varying from 5 per cent to 20 per cent, for sale to the public sector mutual funds and financial institutions. The total number of shares divested during 1991-92 constituted only 8 per cent of the Government holdings in 30 public enterprises at a total value of Rs 30, 38 crores (Public Sector Enterprises Survey, 1992-93, Department of Public Enterprises, Government of India).

In 1996, the Disinvestment Commission was constituted by the Government of India to advice the government on the extent, mode, timing and pricing of

disinvestments. The Commission submitted 12 reports and suggested disinvestment modalities for 58 public sector enterprises, including disinvestments through strategic sale in 29 public sector enterprises, trade sale in eight public sector enterprises, offer of share through GDR and domestic route for five public sector enterprises, no disinvestments differed in 11 public sector enterprises and closure in respect of four public sector enterprises.

In 1996, the Disinvestment Commission was constituted by the Government of India.

In 1999, a separate Department of Disinvestments was constituted under the command of the Union Minister of Disinvestments as a nodal department to streamline and speed up the process of disinvestments. Thereafter, the Government has been disinvesting its equity holdings in public sector enterprises in a planned way by setting up the disinvestments target in the annual plan budget. The present policy of the government is to generally reduce its stake in non-strategic public sector enterprises to 26 per cent (or below, if necessary). The government will retain its majority holding in strategic (i.e. defence related, atomic energy related and railway transport) central public sector undertakings, restructure and revive potentially viable central public sector enterprises and close down central public sector enterprises that cannot be revived.

Brief Survey of Related Studies

The empirical research on the subject of privatization or disinvestments falls mainly into two categories: cross-sectional comparisons of public and private sector performance and statistical analysis of pre and post divestiture performance of the enterprises. Statistical analysis of pre and post-divestiture performance of enterprises forms one of the most widely used methodologies for empirical research on the subject of privatization, and this study will also employ the statistical analysis technique to compare the pre and post-divestiture performance of disinvested central public sector enterprises in India. This section presents a brief survey of the empirical work, at the international as well as country level, in this area.

The first study to be published using this methodology seems to be the study done by Megginson, Nash and Randenborgh (1994) which compares 3-year average post-privatization performance ratios to 3-year pre-privatization values for 61 firms from 18 countries and 32 industries from 1961-89. The study documents economically and statistically significant post-privatization increase in output, operating efficiency, profitability, capital investment spending, and dividend payments; significant decreases in leverage; no evidence of employment declines, but significant changes in firms' directors.

Macquiera and Zurita (1996) compares pre versus post-privatization performance of 22 Chilean firms privatized over 1984-89. The study documents significant increases in output, profitability, employment, investment, and dividend payments.

Boubakri and Cosset (1998) compares 3-year average post-privatization ratios to 3-year pre-privatization values for 79 firms from 21 developing countries and 32 industries from 1980-92. They document significant post-privatization increases in output, operating efficiency, profitability, capital investment, dividend payments, employment and significant decreases in leverage.

D'Souza and Megginson (1999) compares 3-year average post-privatization performance ratios to 3-year pre-privatization from 78 firms from 10 developed countries from 1990-94 and a sub sample of 26 firms. The study documents significant post-privatization increases in output, operating efficiency, profitability, capital investment spending, while leverage and employment decline significantly.

Verbrugge, Megginson and Owens (2000) compare pre and post-privatization performance changes for 32 banks in OECD countries and five in developing countries. The study documents moderate performance improvements in OECD countries.

Boubakri and Cosset (1999) examine pre versus post-privatization performance of 16 African firms privatized through public share offering from 1989-96. They document significant increased capital spending by privatized firms, but find only insignificant changes in profitability, efficiency, output and leverage.

D'Souza and Megginson (2000) examine pre versus post-privatization performance changes for 17 national telecom companies privatized through share offerings during 1981-94. The study documents significant increase in profitability, output, operating efficiency, capital spending, number of access lines and average salary per employee. Leverage and employment are on the decline, but the decline in employment is not statistically significant.

Dewebter and Malatesta (2001) compare pre versus post-privatization performance of 63 large, high-information companies, divested during 1981-94. The study documents significant increases in profitability and significant decreases in leverage and labour intensity.

Boardman, Laurin and Vining (2000) compare 3-year average post-privatization performance ratios to 5-year pre-privatization values for nine Canadian firms privatized during 1988-95. The study documents significant increases in profitability, efficiency and capital spending while leverage and employment decline significantly.

C. Vanlalramsanga (2003) compares the pre and post-disinvestments performance of 26 public sector enterprises in India that experienced partial privatization through the disinvestment programme of the government during the period 1991-92 to 1996-97. The study documents significant increase in the profitability, efficiency and dividend payments for the full sample after disinvestments, while return on assets declined after disinvestments. The study also finds significant decreases in employment level after disinvestments. Indebtedness of divested PSEs is also on the decline but this decline is not significant. Sub samples, where dividing PSEs according to shares disinvested and the sample comparing the PSEs with and without disinvestments, also recorded more or less the same results. The study results, in general, suggest that the disinvestment programme in India yields significant performance improvements on the disinvested public sector enterprises in India.

All of these studies offer least a limited support for the proposition that privatization is associated with significant improvements in divested public sector enterprises.

Data and Sample Collection

The study in this paper was conducted in those central public sector enterprises whose equity shares of 10% or more were disinvested by the central government during 1991-92. Fifteen central public sector enterprises fall in this category, which have annual observation in the year -3 to -1 (pre-disinvestments period) and in the period +1 to +3 (post-disinvestments) selected in the sample, where the year of privatization is defined as year zero (0). The source of data used in this study is exclusively from various issues of the Public Enterprises Survey published annually by the Department of Public Enterprises, Government of India. Details on percentage shares disinvested and percentage of holding of those enterprises covered in the study at the zero year and as on 2.3.2001 are presented in the appendix of this paper.

Methodology

The analysis conducted in this paper seeks to determine whether the disinvestment programme of the central public sector enterprises in India is truly desirable and yields the expected results. The government launched the disinvestment programme with high hopes on what the programme will yield. As has been stated earlier, the government expected that with the disinvestment of the central public sector enterprises they will become significantly efficient, more profitable and financially healthier. This paper will attempt to study whether this, occurred by examining financial ratios of the disinvested central public sector enterprises and comparing the pre and post-disinvestment financial performance of the disinvested central public sector enterprises. The following table presents the testable predictions and the empirical proxies employed in the study:

Table 1 contains the hypotheses, variables and the empirical proxies used to test the hypotheses.

Table 1: Summary of Testable Hypotheses

Characteristics	Proxies	Predicted Relationship
Profitability	Gross profit margin = (Gross profit/net sales)*100	$GPM_A > GPM_B$
	Return on Investment = PBIT/Capital Employed	$ROI_A > ROI_B$
Liquidity	Current ratio = current asset/current liability	$CR_A > CR_B$
Solvency	Debt-equity Ratio = debt/equity	$DER_A <$ DERB
Activity	Capital turnover = net sales/capital employed	$CT_A > CT_B$

Subscript A refers to pre-disinvestment period and subscript B refers to post-disinvestment period.

To test whether the above predictions hold, empirical proxies for every enterprise for a seven year period (three years before through three years after divestment) was computed and then the means and medians of each variable for each enterprise over the pre (-3 to -1) and post-divestment (+1 to +3) periods. The year of divestment [i.e. year zero (0)] was excluded from the analysis. The date of divestment is the date on which the government sold, for the first time, a certain amount of the shares.

Having computed pre and post-disinvestment means for all variables at each enterprise in each group,

Table 2

Variables	N	Mean (median) Pre	Mean (median) Post	Difference (Post-pre) Mean (median)	Percentage of firms that as expected	Z-statistics for significance change
Profitability						
Gross Profit Margin	15	16.459 (14.65)	16.596 (15.38)	0.137 (0.73)	53.33	1.803*
Return on Investment	15	22.739 (17.41)	22.061 (20.61)	–0.678 (3.2)	40.00	0.695
Solvency						
Debt-Equity Ratio	15	3.785 (2.60)	3.806 (3.52)	0.021 (0.92)	40.00	1.376
Liquidity						
Current Ratio	15	1.764 (1.53)	1.874 (1.59)	0.11 (0.06)	66.66	2.539**
Activity						
Capital Turnover	14	2.136 (1.24)	1.765 (1.20)	–0.371 (–0.04)	26.66	–4.962**

**, * indicates significance at 1 per cent and 5 per cent level.

+ figures in the parenthesis are median.

the study employed Wilcoxon Signed-Rank Test as the principal method of testing for significant changes in the variables. This procedure tests whether the median difference in variable values between the pre and post-disinvestments sample is zero. The Wilcoxon test is perhaps one of the most powerful designs among the non-parametric tests (Chou, 1992) for it takes both signs and ranks of differences into consideration, (hence it was called the sign-rank test). Then the study bases its conclusion on the standardized test statistic z.

Empirical Results

Table 2 Summary results for Statistical Analysis comparing pre and post-divestiture performance

This table presents empirical results of the study. For each empirical proxy, the number of observations, the mean and median values of the proxy to and subsequent to disinvestments, the mean and median change in the proxy's value after versus before disinvestments and a test of significance for the change using Wilcoxon Signed Rank Test with z-statistic are presented.

(a) *Profitability changes:* Following divestiture, the profitability of the disinvested central public sector enterprises are expected to increase. The study measures profitability by using Gross Profit Margin (GPM) and Return on Investment (ROI). Gross profit margin measures the relationship between gross profit and net sales, which determines the efficiency with which production and purchase operations are carried on. The study documents a significant increase (at 5% level) in the post-divestiture period, and 53.33 per cent of the disinvested central public sector enterprises taken in the sample experiencing expanding gross profit margin. Another proxy used to measure profitability in this study (i.e. Return on Investment) measures the relationship between profit before interest, and tax and capital employed, which depicts how efficiently the long-term funds supplied by the creditors and shareholders have been used. In other words, Return on Investment indicates the enterprise's ability to generate profit per rupee of capital employed. Higher the ratio, the more efficient the management and utilization of capital employed. The study documents an insignificant decline in the Return on Investment, and only 40 per cent of the disinvested central public sector enterprises selected for the study experienced an expanding Return on Investment.

(b) *Solvency changes:* Following divestiture, the disinvested central public sector enterprises are expected to be more cost and profit conscious. The enterprise's ability to pay on its debts is expected to increase. To measure solvency of the enterprises, the study used debt-equity ratio. The debt-equity ratio measures the relative proportion of debt and equity in financing the assets of the enterprise, and this ratio indicates the margin of safety to long-term creditors. A low debt-equity ratio implies the use of more equity than debt, which means a larger safety margin for creditors.

The Wilcoxon sign rank test shows an insignificant decline of the ration in the post-divestiture period, and 60 per cent of the disinvested central public sector enterprises included in the study experienced a declining solvency in the post-divestiture period.

A low debt-equity ratio implies the use of more equity than debt, which means a larger safety margin for creditors.

(c) *Liquidity changes:* Liquidity conditions of the disinvested central public sector are expected to increase following divestiture. The study measures the liquidity condition of the enterprises by using the current ratio. The current ratio established a relationship between current assets and current liabilities, which measure the ability of the enterprise to meet its short-term obligations. In other words, it measures the safety margin available for short-term creditors. It indicates rupees of current assets available for each rupee of current liability. Higher the ratio, greater the margin of safety for short-term creditors and vice-versa. The study documents a significant increase (at 1% level) in the current ratio in the post-divestiture period, 66.66 per cent of the disinvested central public sector enterprises included in the study experienced an increased liquidity condition during the post-divestiture programme.

(d) *Activity:* Activity ratios are employed to evaluate the efficiency with which the enterprise manages and utilizes its assets, and it is expected to increase after divestiture. The study measures the activity by using capital turnover ratio. The ratio established a relationship between net sales and capital employed to determine the efficiency with which the capital employed is utilized. It indicates the enterprise's ability to generate sales per rupee of capital employed. In general, higher the ratio, the more efficient the management and utilization of capital employed. The study documents a significant decline in capital turnover in the post-divestiture period, and 73.34 per cent of the disinvested central public sector enterprises included in the study experienced declining capital turnover in the post-divestiture period.

Conclusion

The study conducted in this paper compares the pre-and post-divestiture performance of 15 central public sector enterprises in India that experienced partial privatization through the disinvestment programme of the government of India whose equity shares of 10 per cent or more were disinvested during 1991-92. And the study also analyses the trend of the financial and operational performance from 1992-93 to 2000-2001. The study documents a significant increase in the gross profit margin after divestiture, while return on investment is on the decline, although the decline is statistically insignificant. The study also finds an insignificant increase in the debt-equity ratio after divestiture or in other words, solvency is on the decline during the post-divestiture period, although the decline is not significant. Liquidity or current ratio also records a significant increase after the divestiture period, while capital turnover is on the decline. The decline in capital turnover after divestiture is statistically highly significant. Trend analysis shows an increasing trend of the operating income and capital employed, while operating profit is more or less the same over a period of time. The trend analysis also suggests that Return on Investment for the disinvested central public sector enterprises selected for the study are higher than the aggregate of all the central public sector enterprises in India. The Return on Investment for the disinvested central public sector enterprises selected for the study are on the decline over the same period of time.

The significant increase in gross profit margin and current ratio or liquidity confirms the hypotheses, but the decline in Return on Investment and capital turnover are against the hypotheses. Besides, a record increase (even though the increase is not statistically significant) in debt-equity ratio is against the hypothesis. The decline in the Return on Investment and a highly significant decline in capital turnover in the post divestiture period seem to suggest that the efficiency of the management in the disinvested central public sector enterprises selected for the study in utilizing the long-term funds supplied by the creditors and shareholders have deteriorated after the divestiture programme.

To conclude, the findings of this study produce mixed empirical results inducing a measure of caution in statements about the likely effect of privatization, which act as a warning against generalizations about the impact of privatization. In general, privatization of public enterprises is claimed to have delivered improved financial and operational performance but the empirical evidence across the globe also produced mixed results. It may not be injudicious to conclude by saying that the present on-going piecemeal strategy of the disposal of a few equity shares holding of the government in the profit making central public sector enterprises do not affect the financial and operational performance of the disinvested central public sector enterprises, while, at the

same time, sparing those worse hit central public sector enterprises could cause greater financial stress to the central exchequer. But the case of only 15 central public sector enterprises may not be a sufficient case to draw any strong conclusion.

Views and opinions expressed here are personal and do not state or reflect those of the Government of India.

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Appendix

Details of Shares Divested and Percentage of Government Share Holdings of the Public Enterprises Covered in the Study at the Zero Year and as on 2.3.2001

Name of the Enterprises	Year of divestment (Zero year)	% shares divested (zero year)	% shares divested (2.3.2001)	% shares govt. holding (2.3.2001)
Bharat Earth Movers Ltd.	1991-92	20	39.19	60.81
Bharat Electronics Ltd.	1991-92	20	24.14	75.86
Bharat Heavy Electricals Ltd.	1991-92	20.02	32.28	67.72
Bharat Petroleum Corpn. Ltd.	1991-92	20	33.8	66.2
Bongaigaon Ref. & Petro. Chem. Ltd.	1991-92	20.02	25.54	74.46
CMC Ltd.	1991-92	16.5	16.69	83.31
Hindustan Organic Chem. Ltd.	1991-92	20.06	41.39	58.61
Hindustan Petroleum Corpn.	1991-92	20.05	48.94	51.06
VSNL	1991-92	15	47	53
Hindustan Zinc Ltd.	1991-92	19.95	24.08	75.92
Indian Petrochemicals Corp. Ltd.	1991-92	20	40.05	59.95
Indian Telephone Industries	1991-92	19.89	22.98	77.02
Madras Refineries Ltd.	1991-92	16.91	16.91	16.92
MTNL	1991-92	20	43.8	56.2
Shipping Corpn. of India	1991-92	18.49	19.88	80.12

□

The absence of alternatives clears the mind marvelously.

– Henry Kissinger

Feature

HR Challenges in the Power Sector

Srinivas R. Kandula

This paper proposes a series of well connected human resource actions that augment power sector development. After dealing with the existing power sector scenario the article goes on to discuss the emerging new order in this sector. The implication of reforms to power sector organisations are discussed as well as the existing scenario of human resource management. The emerging human resource management challenges are also dealt with.

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Despite fifty-fold increase in capacity addition of power generation during the last fifty years, the country is witnessing a substantial power shortage, necessitating unprecedented rapid progress in the sector. The power sector needs to be toned up in all the three spheres: generation, transmission and distribution. This involves huge investment not only in terms of financial and material resources but also in nurturing and developing human resource competencies.

Customised technical and managerial competencies suitable to the power sector are scarce though manpower with generic aptitude is available in abundance in the country. Unless the right steps are taken to attract, develop, deploy, motivate and retain the right quality and quantity of human resources, the national goal of achieving capacity addition, realising an efficient power network and enhancing consumer satisfaction, will remain an impossible task. There is widespread agreement among policy makers and professionals of the power sector that there must be a well defined human resources strategy capable of realising this national goal of capacity addition in generation, transmission and distribution sectors, apart from enhancing consumer satisfaction.

The power sector in India is plagued by several problems. The following facts and figures amply demonstrate the disturbing scenario of the sector:

- Inadequate power generation capacity
- Lack of optimum utilization of the existing generation capacity
- Inadequate inter-regional transmission links
- The annual losses of SEBs have reached Rs. 33,000 crores, i.e., 1.5 per cent of GDP
- The outstanding amount due to the CPSUs has grown to over Rs. 40,000 crores, seriously hampering the capacity addition programme
- Out of the total power generated only about 55 per cent is billed and only about 41 percent is

realized. At present, SEBs loose nearly 110 paise for every unit of electricity sold

- The industry in India has among the highest tariffs in the world and is not assured of the quality of supply
- In the last two five year plans, barely half of the capacity addition planned was achieved. The optimistic expectations from the IPPs have not been fulfilled
- Only 55 per cent of households in India have access to electricity. Access is yet to be provided to over 80,000 villages. Most of those who have access do not get uninterrupted power supply.
- The sector has become financially weak and unviable
- The energy as well as peaking shortages across the country is a matter of serious concern. There is lack of grid discipline.

In order to achieve rapid and sustainable progress, the Government of India has initiated several measures. These are:

Ministry of power, Government of India, has firmed up plans to add 1 lakh MW capacity during the X and XI plans i.e., by 2012. This means, we need to double the existing capacity of 1 lakh MW that was created in a span of five decades into one decade. State sector is expected to add about 60,000 MW and the remaining 40,000 MW by private sector.

In order to match the growth of generation capacity, a matching transmission capability is to be built. The perspective plan envisages building a 30,000 MW inter-region transmission capability by 2012. This perspective plan envisages building a 30,000 MW inter-region transmission capability by 2012. This involves an investment of about Rs. 2,00,000 crores for creating a transmission system, including the formation of a National Power Grid. Out of this, an investment of Rs. 70,000 crores would be required in the Central Sector Transmission Systems alone. Powergrid is expected to mobilise an investment of Rs. 41,000 crores from its own resources. The balance requirement of 29,000 crores is proposed to be mobilised through private investment.

In order to realise these mega plans, the following significant actions have been taken:

The Electricity Act, 2003

With a view to deregulate the power sector, Government of India has notified 'The Electricity Act, 2003' which came in to force with effect from 10th June, 2003, replacing three existing legislations, namely, the Indian Electricity Act, 1910, The Electricity (Supply) Act, 1948, and The Electricity Regulatory Commission Act, 1998. The objectives of the Act are:

To consolidate the laws relating to generation, transmission, distribution, trading and use of electricity and generally for taking measures conducive to the development of the electricity industry, promoting competition therein, protecting interest of consumers and supply of electricity to all areas, rationalization of electricity tariff, ensuring transparent policies regarding subsidies, promotion of efficient and environmentally benign policies, constitution of Central Electricity Authority, Regulatory Commissions and Establishment of Appellate Tribunal, and for matters connected therewith or incidental thereto.

The salient features of this legislation include: delicensing of generation, easing of captive power norms, introduction of open access to the transmission and distribution network, transparent subsidy management, stringent anti theft measures, speeding up of rural electrification, provision of independent regulators at the state and central level and constitution of appellate authorities. As a sequel to this reform process, the Government of India is also expected to release four vital documents. These are:

1. National Electricity Policy
2. National Electricity Tariff Policy
3. Rural Electricity Supply Policy
4. Policy for allowing more than One Licensee for One Area of Operation/Distribution.

Task Force on Power Sector Investment and Reform Process

Realization of power sector goals as discussed above involves an estimated investment of Rs. 8,00,000 crores in the current decade. The investors have been wary of the sector due to lack of confidence in getting returns on their investments. Keeping in view this situation and to analyze the existing investment climate in the power sector and suggest measures for promoting and facilitating private investments, both domestic and foreign, as well as to ensure the implementation of the reform process, the Government of India has constituted a Task force on 'Power Sector Investment and Reform Process' under the chairmanship of Shri N.P. Singh, Member, Planning Commission. The said task force is expected to submit its report by December 2003.

Six Level Intervention Strategy

The Ministry of Power has formulated a six level intervention strategy as shown in Figure 1 to achieve the viability of SEBs and to give a fillip to the implementation of the Reform Process. This six level intervention strategy encompasses the following:

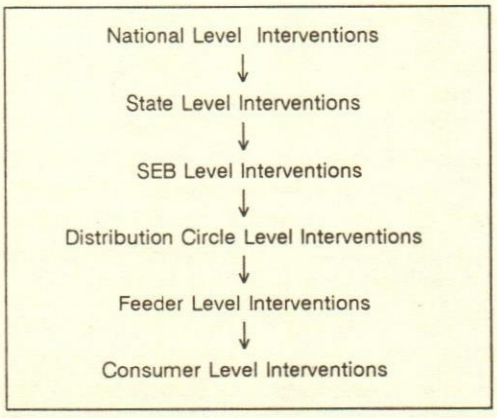

Fig. 1. Six Level Intervention Strategy

1. *National Level Interventions:* The national level intervention include providing for a legal framework for ushering distribution reforms like enabling local institutions to manage distribution, third party sale, remote metering, removal of cross subsidies, penal provisions for thefts etc.
2. *State Level Interventions:* The states are being asked to sign MOUs with the Ministry of Power to set up State Electricity Regulatory Commissions, restructure SEBs, remove cross subsidies and, introduce privatisation. So far 27 states have signed MOUs with the Ministry of Power, except Manipur and Tripura, 22 states have constituted SERCs and 10 States have unbundled SEBs viz: Delhi, Rajasthan, Haryana, Uttar Pradesh, Uttaranchal, Madhya Pradesh, Andhra Pradesh, Karnataka, Orissa and West Bengal.
3. *SEB Level Interventions :* SEBs are being insisted upon to sign MOAs with the Ministry of Power to carry out distribution reforms. This involves introduction of commercial accounting, setting up of online management information systems, introduction of benchmarking of crucial parameters that cover consumer satisfaction and system stability. Till now, 27 states have signed the MOA.
4. *Distribution Circle Level Interventions:* Each circle is expected to work as a distinct profit centre with the Superintending Engineer as the CEO of the circle.
5. *Feeder Level Interventions:* 11 KV feeders will be operated as business units that will be accountable for the quality of power and reliability, metering, billing and collection.
6. *Consumer Level Interventions:* Mandatory metering with a digital interface for all consumers, prepaid metering, incentives for energy efficiency, are envisaged here.

Accelerated Power Development and Reform Programme (APDRP)

Government of India has approved the expenditure of Rs. 40,000 crores during the tenth plan for the implementation of the above discussed six level intervention strategy under the "APDRP" scheme. An outlay of Rs. 20,000 crores has been provided as central plan assistance under APDRP to State Governments for implementing the up gradation and modernization of sub transmission and distribution schemes.

Implications of Power Sector Reforms

Power sector reforms and developments as discussed above have significant implications on the way power sector organisations are managed. The pre reform period offered power sector organisations many a privilege in the form of regulation and protection, bestowing on them virtually a monopolistic status. The globalization, liberalization and changes in markets, marked by competition and borderless resource mobilization, have stripped the power sector organisations of all its monopolistic privileges. Unless organisations adapt to the pace and spirit of the reform programme, they will become non-existent. Organisations need to initiate large-scale changes in three principal spheres of management such as depicted in Fig. 2 and discussed here:

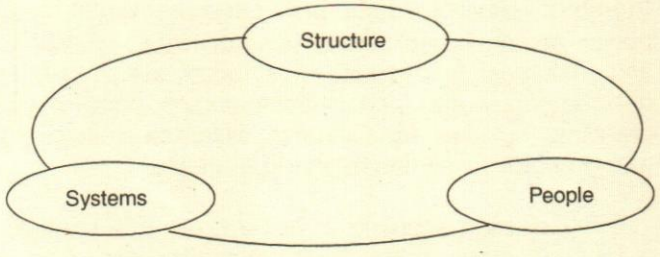

Fig. 2. Implications of Reforms to Power Sector Organisations

Structure: Reforms chiefly envisage massive capacity additions as discussed above. In this context, power sector organisations have a critical role. They need to act swiftly to mobilize funds, execute and commission projects with efficiency. Presently, most of these organisations are saddled with bureaucratic organisa-

tional structures involving tall hierarchies, debilitating fast decision-making, communication and implementation of assignments in real time. Therefore, there is an immediate need to restructure the organisational hierarchies into functional ones. Further, power sector organisations, especially in the state sector, are large sized corporations with a centralized budgeting, accounting and balance sheet. In order to manage it effectively, operations are required to be organized into strategic business units.

There is an immediate need to restructure the organisational hierarchies into functional ones.

Systems: The reform programme also expects power organisations to bring greater efficiency in their activities, operations and assets, for resource optimization. Many of the systems that exist in these organisations such as operational procedures, quality system, finance and human resource system, planning, monitoring and project execution, are decades old though there is an attempt to revise them. In consonance with world class benchmarking practices, these organisations are required to make massive efforts to refine and put in place a systematic 'systems management' framework. The implementation processes must also be thoroughly overhauled to ensure execution of the laid down systems with high precision.

People: The third component that involves significant efforts is preparing, nurturing and ensuring availability of right quality and quantity of human resources to augment the reform process. This single factor has the potential to derail the entire reform progress if adequate efforts are not devoted to address the issue. Currently, human resource policy and practice in many power sector organisations is administrative, welfare and maintenance oriented. This focus has to shift to developmental and performance centric policies and practices so that right human resource suiting the power sector plans can be made available.

The existing scenario of human resource management in the power sector is far from satisfactory. Ageing manpower, insufficient availability of right skills and competencies and inadequate preparation of human resources in the backdrop of restructuring of the power sector, especially the unbundling of SEBs, has contributed to a conflictive human relations scenario on one side and a sagging morale of people on the other side. The following issues amply reflect the state of the existing scenario of human resource management:

- *Outdated HR Policy Framework:* The basic policy framework of human resource management followed in the power sector, especially in the state sector, is decades old. Efforts have not been made to review the basic assumptions and tenets of this policy framework though there were attempts to revise a few individual human resource policies. The overall objective, purpose and direction of the human resource function is ambiguous.
- *HR as an end in itself:* The existing human resource function neither has a sharp linkage with business plans of organisations nor has customer orientation. Due to this, many human resource activities take place as an end in themselves rather than as a means to serve employee and organisational purposes. As a result, many human resource activities are managed in a way that is devoid of business value.
- *HR as Piecemeal:* Integration among various human resource functions is evidently absent. Many human resource functions are implemented in a piecemeal manner and there is a watertight compartmental approach in the management of HR functions. Due to this, at times they duplicate the efforts and also work in different directions causing confusion and diminishing value. It is also no surprise to notice the conflicting objectives of these independent human resource functions. In a nutshell, these rules lack a system approach to human resource management.
- *Regulation orientated:* There is greater emphasis on compliance to procedures than on obtaining results. Many human resource professionals in the power sector understand their role as simply implementing the rules and regulations rather than thinking their role is one of value adding through building human resource skills. This approach has contributed to adding more and more rules and regulations rather than adapting a contemporary approach to the management of human resources. The regulation orientation leaves too little flexibility, constraining the right decision-making.
- *Administrative Focused:* This factor is a sequel to the regulation orientation. Many of the current human resource practices are routine and administrative oriented. These are referred to as the 'establishment function' in power sector organisations. Disproportionate importance is attached to these activities resulting in loss of efforts and attention to business driven human resource functions like performance management, competency building and other motivational management issues.
- *Welfare Focused:* There is a myth that welfare ac-

tivities simply assure good performance. As opposed to this, a socialistic pattern of welfare can yield counter productive results for the organisation. There is no doubt that there must be sound practices ensuring the welfare and security of human resources. This must be done judiciously and as a factor of employee performance rather than in a philosophical manner.

Socialistic pattern of welfare can yield counter productive results for the organisation.

- *IR/Collective Bargaining Focused:* As of now, collective bargaining forums are used only for the purpose of negotiating compensation and other workmen related policies. These forums are understood as a mechanism to ensure harmonious industrial relations rather than leveraging them for enhancing employee and organisational performance through their involvement in disseminating the business agenda of power sector organisations.
- *Subjectivity Perception:* An interesting aspect is, though human resource management is state dominated power sector organisations are regulation oriented. Many of these policies leave many situations and contexts undefined. This ambiguity has given scope for the generation of distrust and perception of arbitrariness in human resource related decisions. Unless this subjectivity is controlled through well-defined objective systems, human resource functions could fail to deliver.
- *Absence of Business Driven HR Practices:* Many human resource practices and the way they are managed are decades old. For example, in many organisations a manual system prevails in the place of systematic information technology enabled human resource data management. None of the functions such as recruitment, career planning, training and compensation, are sharply tied to business goals. A great number of human resource activities are managed and pursued by independent human resource personnel rather than by devolving the functions across the organisation through active involvement of line managers.

There is an immediate need in the backdrop of power sector reforms that this state of conventional human resource management be transformed into business driven and employee development focused human resource system. There is no doubt that the lack of a scientific human resource system can adversely affect the reform programme and survival of power sector organisations in the era of free trade and customer dictated business scenario. This requires, power sector organisations to initiate not a single action but a series of well-connected actions.

Human Resource Management Model for Power Sector

The analysis of the existing human resource scenario clearly brings out the necessity for large-scale change not only in the overall approach to human resource management but also in individual human practices. Emerging business order of the power sector fuelled by reform programme calls for greater optimization of human resources, building requisite human resource skills and competencies, managing people for superior performance, inculcating quality and customer delight oriented practices, involving line managers as partners of HR and bringing a scientific system approach to HR functions, especially building the business-human resource linkage at the micro and macro levels.

- Defining Human Resource Model

Every power sector organisation in tune with its business vision, mission and objectives in short, medium and long terms should design the human resource model. This model will act as the basis for design and implementation of various human resource practices. This implies that the overall focus of the human resource model must run across every individual human resource practice bearing the imprint of such a model. For this purpose, organisations need to take stock of the prevailing scenario of human resource management, identify the gaps and put in place a business driven human resource model. This model must be self explanatory with regard to its focus, objectives and approach for managing the people. What we have to do in power sector organisations, especially in SEBs, is disjointed and highly administrative focused personnel practices rather than meaningful and performance oriented human resource management. The following must be reckoned while designing the human resource model:

- *Devolvement Orientation:* Human resource functions, especially execution, must be devolved to line managers. Unless, there is a greater involvement and participation of line managers, realizing the human resource model will remain a dream.
- *Customer Orientation:* Human resource framework must be built with 'customer delight'

as a basic building block. This can resolve many implementation challenges and avert execution pitfalls. Further, this is a sure shot for improving the quality of human resource management.

- *System Orientation:* Human Resource Management is a distinct discipline with its own fundamentals. Therefore, human resource management in an organisational context like the power sector should be practiced as a system of management rather than in an unsystematic and individualized fashion. There must be a linkage and clear flow of activities from talent sourcing to the strategic separation of human resources. There must be consistency, objectivity and equity in people management that leaves no scope for irrational arbitrariness.
- *Process Orientation:* Human resource model must give specific attention to the issue of 'processes'. This means, not only should the HR model define the objectives but the way these objectives can be attained also be spelt out. Many times, how it is done is more important than what is done. This 'how' aspect (referred to as process in this context) should be taken care of.
- *Outsourcing Peripheral Services:* The new HR model must keep in view a vital aspect i.e. outsourcing the peripheral services as much as possible. Some of the services hitherto managed by HR departments in-house such as dispatch, transport, event management, house keeping, security, guest house and office building maintenance, and other welfare functions can be outsourced for cost efficiency and to help the HR people focus on the main issues.
- *HR Audit & Appraisals:* Human resource management model as well as practices shall be subject to audit and appraisal at regular intervals in order to revitalize it according to the changing environment. This apart from helping to bring right modifications at the right time also presents an opportunity to ensure transparence in human resource management.
- *Training of Human Resource Professionals:* Many human resource professionals in power sector organisations are equipped to perform traditional HR roles and deal with the existing framework of human resource management only. They need to be exposed to the business driven human resource practices like competency building, performance management, assessment centres, human resource accounting and survey methodologies. It is also required that human resource professionals must posses knowledge in line operations of the power sector for better appreciation of the ground realities. Further, time has come for human resource professionals to perform a more change agent role than as custodians of status quo. Hence, training of human resource professionals as a part of building a business driven HR model must be given top priority.

- Design and Implementation of Human Resource Practices
  - Many of the existing human resource practices in the power sector are administrative and regulation oriented rather than developmental and business driven. Therefore, this orientation needs to be replaced with contemporary and value added human resource practices such as:

Existing human resource practices in the power sector are administrative and regulation oriented rather than developmental and business driven.

  - *Human Resource Planning:* This is a much neglected area in the power sector. Age old man power norms are still followed for the deployment of people. Power technologies and the way they are operated have undergone many changes. Therefore, power sector organisations need to implement human resource planning studies with the help of experts and re-set the manpower norms and draw real job specifications and descriptions. Implementation of fresh human resource planning can contribute towards the optimization of the manpower to a great extent.
  - *Human Resource Information System:* Many power sector organisations are yet to build a systematic data base management. The absence of a human resource information system deprived many organisations from optimal utilization of manpower, apart from many human resource related decisions lacking the support of objective data. Therefore, this issue must be given due attention for building IT enabled human resource information, either internally or with the help of external agencies.
  - *Talent Sourcing:* There is heavy competition in the talent market for sourcing people with the right profile. This competition is really global as

today's younger generation is ready to move and work in any part of the world. Therefore, the power sector needs to compete with MNCs and other high profile organisations to attract the talent. Power sector organisations need to source manpower in order to implement the national agenda of additional capacity creation. This pre supposes that power sector organisations must develop cost effective and technology supported recruitment systems that facilitate quick sourcing of the right manpower.

- *Skill & Competency Development:* The reform process envisages massive capacity addition in all the segments: generation, transmission and distribution. Further, there is an emphasis on the optimization of the existing capacity. This involves creating a large pool of talent possessing the right technical skills and competencies. Substantial investment is required to set up training institutes and infrastructure capable of imparting skills and creating competencies. Organisations also need to develop customized course modules, courseware, training methodology, faculty development and training evaluation procedures. Further, there must be retraining programmes to enable the existing workforce to obtain technologically relevant skills. In this context, National Training Policy for Power Sector, especially various guidelines and benchmarks provided in this policy, can be of great help to power sector organisations. Power sector organisations need to allocate adequate resources and create a business aligned training policy without any delay.

- *Inter Personal Competency Building:* A special emphasis is accorded to customer delight in power sector reforms. This assumes more importance in the distribution sector. Changing mindsets of thousands of employees working in SEBs in order to inculcate customer focus solicits mammoth efforts. This can be achieved by imparting inter personal competency. Power sector organisations must focus on this issue and devise a plan for exposing all the employees in a phased manner to a structured training initiative. Though it is a part of skill and competency building initiatives as discussed above, this issue needs to be given special emphasis due to the current low level of customer satisfaction.

- *Performance Driven Incentives:* Almost 95 per cent of employee compensation in power sector organisations is fixed. This means, regardless of actual performance, every employee gets paid the same compensation. In order to nurture a performance-orientated culture, power sector organisations must develop their own system of variable pay since measurement of performance differs from organisation to organisation depending upon its context and type of operation like generation, transmission and distribution.

To nurture a performance-orientated culture, power sector organisations must develop their own system of variable pay.

- *Performance Appraisal System:* Setting Key Results Areas (KRA) and monitoring its achievement is a missing aspect in power sector organisations. Further, many SEBs are still following the old system of confidential reports, which need to be discontinued in favour of a more systematic performance appraisal system. Unless, the performance appraisal is made objective, adhering to the KRA approach, utilization of human skills and competencies will remain elusive. The skills and competency building also should be closely linked to the appraisal of KRAs.

- *Career Development:* There is no denying the fact that there is considerable stagnation at many levels in power sector organisations given the historical background. It is a challenging task to address this issue to the satisfaction of all employees. Avoiding this issue can cause loss of employee morale, adversely affecting productivity. The traditional method of promoting people at regular intervals based on seniority can no longer work in power sector organisations. In line with organisational structures and emphasis on competency centric human resource management, traditional vertical career management must be replaced by job enrichment oriented careers and functional specializations.

- *High Performance Work Practices:* In line with the changing human resource profile i.e. gradual shift from blue collar work force to white collar and knowledge driven human resources, high performance work practices like communication, employee involvement, empowerment, multi skilling, job rotations, flexi work schedules etc., must be implemented. Power sector organisations need to develop

communication and empowerment policies and implement them. Unless employees are effectively communicated the business mission and priorities and unless they are empowered to execute these, the national goal of capacity additions and optimization of resource will remain on paper.

- *Leadership Development:* What the power sector presently needs is leaders rather than managers. People, who can take the initiative, think beyond conventional lines, adopt an out of box approach can achieve the targets in a fast changing power sector environment. Therefore, efforts must be made to build the leadership at various levels of organisations.
- *Redundancy Management:* Power sector organisations, especially in state sectors like SEBs, are decades old. These organisations do carry some manpower which is neither trainable nor can be used in any way given the widespread changes in the sector. It is also a fact that many of these employees have given valuable contribution during their productive years. Therefore, every organisation must search for its own way to separate these employees without pain. Golden handshakes and voluntary retirement schemes must be introduced. Further, this redundancy management approach also must be used to bring down the average age of manpower through the right inductions.

There is ample evidence in support of the fact that weak human resource management policy and practice is the single most influential factor for the derailment of business plans. In this backdrop, there is no need to emphasize the fundamental role of human resource management in enabling power sector organisations to achieve its business goals. Unless, power sector organisations develop human resource capabilities to achieve their business plans, the national mandate of adding 1 lakh MW and creating a matching transmission and distribution network may be difficult. In this context, the HR model and practices described above can be of practical use to power sector organisations in implementing systematic human resource management in the emerging business order. □

Our lives begin to end the day we become silent about things that matter.

– Martin Luther King, Jr.

Feature

MNCs & Human Capital Accretion in the Software Industry

Ajit P. Nair & V.S. Pai

This paper is an attempt to create a theoretical construct relating human capital to software industry in India. The paper traces the evolution of the Indian Software industry in terms of human capital accretion. The initial supply of human capital—defined as available software professionals—lead to entry of Multinational corporations (MNCs). This triggered an overall process of further human capital accretion governed by market structure dynamics. The study concludes that spillovers from MNC operations are more effective when MNCs operate at the higher end of technology and build backward linkages with local firms and institutions in a developing economy.

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In the last decade the Indian software industry has witnessed unprecedented growth. Following the 1991 economic reforms this industry expanded rapidly, in pursuit of meeting the global demand for IT services assisted by an abundant supply of highly skilled but low-cost labour. However, India has captured only a small portion of the global software industry, estimated at about $ 400 billion in 2000 (Arora & Athreye, 2001). Indian export of software services in 1990-91 was $128 million, which rapidly increased and in 2001 accounted for $8.3 billion (Nasscom). The domestic market in 2001 was estimated to be $2.5 billion in revenues. The national IT Task Force has set a target of US $50 billion of annual software and services exports by 2008; domestically the goal has been set at $35 billion. Software exports today are an important source of foreign exchange and currently such exports comprise about 16.3% of total exports and the IT industry overall represents 2.87% of India's GDP (Table 1).

The industry's export of services, which started at the low end of data feeding and onsite projects in the 1980s have moved up the value chain. From body shopping it has moved to offshore development, niche products and software consultancy services by the beginning of the millennium (Nasscom Report, 2000).

In the case of India, the initial contribution of human capital, and technological capabilities of local educational and research institutions determined the entry and nature of operations of software MNCs. At present, India's educational institutions annually generate about 100,000 software professionals of varying technical skills with English language proficiency. About 20,000 engineering graduates are produced by the formal institutes, and rest by the private training institutes. Some world-class research institutions support this pool of skilled labour, which ultimately has provided a major incentive for MNCs to enter India to tap the existing as well as growing pool of low-cost high-skilled work force (Arora & Athreya, 2001).

The competitiveness of the Indian software industry is generally attributed to the low cost of scientific and engineering manpower with English language skills (Hanna, 1994; Heeks, 1996). The industry has been able to achieve export competitiveness without a domestic market base, inefficient input industries and basic infrastructure of telecommunications (Ghemawat & Patibandla, 1999; Patibandla et al, 2000). The main input for this competitive growth has been human capital.

Table 1: IT Industry in India-(Software, Hardware, Peripherals)

	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00
	Rs. M*	Rs. M	Rs. M	Rs. M	Rs. M	Rs. M
Software						
Domestic	10,700	16,700	24,100	35,100	49,500	72,000
Exports	15,350	25,200	39,000	65,300	109,400	171,500
Total	26,050	41,900	63,100	100,400	158,900	243,500
Hardware						
Domestic	18,300	35,600	37,800	44,970	42,350	62,000
Exports	5,500	1,200	10,300	7,430	155	3,700
Total	23,800	36,800	48,100	52,400	42,505	65,700
Peripherals						
Domestic	4,590	6,720	6,530	8,330	13,600	18,700
Exports	180	210	520	680	730	1,150
Total	4,770	6,930	7.050	9,010	14,330	19,850
Training	3,310	4,970	6,600	9,420	12,500	17,200
Main-tenance	4,400	5,920	6,560	8,240	9,780	11,300
Networking & others		2,400	5,590	7,150	9,800	13,250
Grand Total	63,450	98,920	137,000	186,620	247,815	370,800

Source: Nasscom, www.nasscom.org

* million

The study was undertaken to examine in the Indian context whether entry of software MNCs has resulted in human capital accumulation in the industry. Also, whether MNCs with backward and forward linkages in the Indian economy are more beneficial than those which operate as highly integrated units.

Methodology

The rationale of this study is to understand the dynamics of the software industry from the perspective of human capital accretion. The arguments in the paper are being linked with three case studies of MNC software investments in India, namely, Texas instruments, Motorola, Nortel and their overall collective effect in transforming the Indian software industry. The study is based on secondary data collected from newspapers, magazines, internet, websites and through interviews with executives working in these respective companies. These secondary data are divided into two categories—one representing MNC subsidiaries and the other, Indian firms.

The focus of the data collected from the MNCs is to assess the level of technology of their operations, backward and forward linkages with local firms, educational institutions, as also their plans for growth and technology upgradation in the Indian operations. The focus for the local firms is on the issue of the benefits, if any, of their collaborations with MNCs. We then discuss the MNCs to highlight certain general patterns of their operations and examine its implications on human capital accretion and growth of the industry in India linked to spillovers. A spillover is a part of an economic growth process, which could ideally increase the skills of workers (for a given situation), with competitive input and available market conditions. This would have a likely impact on the existing wages and incomes. This further acts as an incentive for the local manpower to acquire industry specific skill sets, thereby increasing the pool of local skilled manpower. Spillovers cause growth of the local industry leading to further and better FDI inflow, especially from MNCs to India, leading to further spillovers.

Issues in Human Capital Accretion

The definition of the evolution of the software industry is in terms of increase in workers' output and increase in industry dimensions. Increase in the industry would be defined as increase in employment and total revenues. An increase in total revenues is caused by increase in workers' output over time and the skill effect of the increase in number of skilled workers. Workers' output is a function of capital accretion and technological change. Lucas (1988) has suggested separating capital into physical capital and human capital. In this case the focus is on human capital accretion although physical capital plays an essential, but secondary role. (Cantwell, 1989; Lall, 1992; Aitken & Harrison, 1999; Dunning, J.H., & Narula, R. 1996, Coe & Helpman, 1995; Rotenberg & Saloner, 2000; Teece, 1977). Human capital formation takes place in schools, in research organisations and in the course of producing goods and engaging in trade.

Most technological change in terms of new products and ideas are generated in developed

economies. A major part of the economic growth in developing economies is a matter of importing and imitating new technologies from developed economies. Open policies toward international trade and multinational investment is a major source of technological and knowledge diffusion (spillovers) to developing economies (Romer, 1990; Grossman & Helpman, 1991, Patibandla and Petersen, 2000).

A major part of the economic growth in developing economies is a matter of importing and imitating new technologies from developed economies.

Local firms and workers in developing economies need to have basic capabilities to absorb new technologies and ideas in order to benefit from international investment. Lall (1992) groups these capabilities under three broad headings; physical investment, human capital and technological effort. This would imply that in the context of rapid technological change, firms in developing economies should be able to replace older technological resources and train workers in a sustained manner. In the software industry, production activity would lead to technological learning; while in manufacturing the learning costs and the time period required are very significant in a complex manufacturing system. Therefore, technological capacity building in the IT industry context is basic skills of workers acquired in the educational institutions (universities) and the ability of firms to train and retrain workers on new technologies rather than replacing physical capital. Thus, the initial supply of human capital determines the entry and the level of technology brought in by MNCs.

The higher-end technology—such as investing in research and development—causes higher degree of spillovers than the low-end operations of MNCs, such as data feeding and coding operations. The dynamic process of the evolution of the industry in response to entry of MNCs has to be seen as an interplay of firm level (Lall, 1992) and market structure dynamics (Rotenberg & Saloner, 2000) in conjunction with overall market institutional conditions (Williamson, 1998). This involves issues such as firm-level technology efforts, competition, exports and domestic market conditions.

The higher-end technology—such as investing in research and development—causes higher degree of spillovers than the low-end operations.

Thus the market structure dynamics states, larger the number of firms higher is the motivation for workers to acquire both general and special skills. A small market size restricts the number of firms to a few which can give predatory power to firms which pay skilled workers wages at par with unskilled workers. This discourages skilled labour to acquire specialized skills (Rotenberg & Saloner, 2000). Export direction increases the market size and facilitates a large number of firms to enter the industry. The larger the number of firms, larger the spilling over effect, because MNCs bring in differentiated inputs and technologies (Romer, 1990). This, in turn, leads to a higher degree of spillovers to local industry and workers. Different MNCs train local workers on different technologies, which results in a diverse range of skills in the local industry. Export-oriented firms forming a group cause faster aggregate human capital accretion.

High-tech industry clusters would lead to agglomeration economies, which contribute to aggregate human capital accretion. Agglomeration economies mean that for given inputs, the output of an individual firm is larger than the aggregate output of other firms producing the same good in the same region (Patibandla and Petersen, 2000). Export direction relaxes the market size limitation, and thus increases the number of firms in a group. The cluster activity increases spilling over effects of diffusion of technologies and new ideas with ease because of concentration of a large number of high-tech industry firms within a geographic region. This is especially important if knowledge is tacit and uncodified (Baptista, 2000), and therefore requires close interface among skilled workers.

Mobility of skilled and experienced workers facilitates the free flow of new ideas and knowledge, which, in turn, increases the aggregate human capital structure (Porter, 1990; Saxenian, 1996). A group also facilitates firms to hire workers with experience and skills more suitable to the requirements in the perspective of rapid technological changes. Transaction costs of exchange tend to be high in developing economies owing to the presence of inefficient market institutions (Williamson, 1998). Bunch activity might solve a part of this by facilitating closer and repeated interactions among agents and thereby reducing costs of formulating and enforcing contracts. This, in turn, facilitates contracting out work to other firms depending on their corresponding skills. This is especially evident if firms in the group are not competing for the small local market, but are international trade oriented.

Mobility of skilled and experienced workers facilitates the free flow of new ideas and knowledge.

Larger forward and backward linkages of MNCs with the local industry cause a higher level of spillovers than MNCs operating as stand alones in a developing economy. Backward linkages would be linkages with human capital generating institutions such as universities, research labs, and with firms that produce corresponding inputs and services. Forward linkages for an export leaning, high-tech industry in a developing economy involves linkage with the home and international market operations of MNCs. A MNC that builds effective backward linkages stimulates further investment and development and generates knowledge spillovers in technology and organisational practices (Kobrin, 1999; UNCTAD, 2001).

Linkages of MNCs with local firms could be at the lower-end and higher-end of technologies. Linkages at the higher-end technologies require two main conditions; (i) local firms and workers need to have minimum technological capabilities and skills (Lall, 1992), and (ii) prevailing market institutions have to facilitate formulation and enforcement of complex contracts with low transaction costs (Williamson, 1998), besides protection of intellectual property rights (Teece, 1977). The larger the technology gap between local firms and industry, the lower is the realization of knowledge spillovers (Blomstrom & Sjoholm, 1999). For private firms to utilize and absorb this knowledge, they have to make their own private efforts in research and development and employee training (Coe & Helpman, 1995). In a developing country spillovers from MNC operations can be turned into effective public goods, if the government undertakes investment in public goods of higher education and research and development.

In a developing country spillovers from MNC operations can be turned into effective public goods.

MNC investments in the lower-end technology in a developing economy contribute negatively to human capital accretion; the low-wage cost of skilled labour induces MNCs to invest in lower-end services, which leads to under utilization of human capital in a developing economy. Lower-end technologies have low-level learning economies on the job and also exhibit a lower level of knowledge diffusion. Hence MNCs, by paying a slightly higher current wage than other sectors with higher learning economies, may avoid other sectors, which have higher potential contribution to growth.

Case Analysis

The MNCs' investments in India are basically in the fields of IT-enabled services, offshore software development (programming), and R&D investments; like medical transcription, BPO, call centres. These different segments require different levels of labour skills and sophistication. The IT-enabled services are the least skill intensive and programming ideally requires basic skills, while the other segments require highly specialized skills.

In the case of research and development, MNCs operate both at the low-end and high-end. At the lower-end of R&D, MNCs could get into collaboration with local firms by subcontracting the work. At the higher-end most of the work is done in-house in the Indian subsidiaries with the R&D teams. For example, in telecom-related software, MNCs such as Nortel got into joint ventures with large local firms for R&D to make use of the complementary skills of the local firms at low costs under carefully formulated contracts for protecting intellectual property rights (Basant et al, 1998). Now, we discuss three case studies of MNC operations in India, drawn from a population of firms.

Texas Instruments (TI)

A subsidiary of TI was set up in Bangalore in 1985. During those times, the government did not permit private firms to own and install their own satellite communication facilities. TI's managers brought in the most modern communication equipment available—a 64 khps data link—and gave it to the government (the Department of Telecommunications—DOT). They, in turn, then got the link from the DOT for TI operations. At this time the idea of Software Technology Parks was formulated to provide satellite and other infrastructure facilities to the Indian software industry. The communication facilities made it possible for the R&D teams in Bangalore to be in direct and real time contact with the parent operations in the US. The excess capacity on the Satellite link in the beginning allowed local firms get the link and facilitated their movement from onsite projects to offshore development. The Indian TI subsidiary today recruits highly skilled labour from the Indian Institute of Technologies and Regional Engineering Colleges (RECs) and from Indian Institute of Science (IISc). The HR practices of TI (India) are characterized by a flat organisational structure, as well as by team and

individual-based incentives for promotion. Once recruited, employees are involved in project training. Due to its HR policies, the attrition rate is observed to be at 15%, much below the existent industry average. As TI (India) is into high-end R&D, which requires strong synergy between different departments of chip designing and chip related software development, it concentrates its work in one unit in Bangalore.

The TI subsidiary has developed strong linkages with the universities and research labs in and around Bangalore, e.g., through funding establishment of research labs in about twenty universities and through collaboration with university professors in designing and upgrading the curriculum of engineering education. Because the TI subsidiary carries out high-level R&D in chip designing and digital signal processing, it does not often out-source high-level R&D in chip designing and digital signal processing to local firms. They undertake outsourcing to four or five firms for short-term projects for which they do not want to hire people. The subsidiary, which started with about twenty-three engineers, employs more than five hundred highly trained engineers now.

The two significant contributions to TI are the spillover effects to local firms and the sophisticated telecom links. The TI operations with modern communication links helped some of the large local firms such as Tata Consultancy Services and Wipro to undertake TI's practices and move toward offshore development. Second, TI's successful operation in India had a positive impact on other US and European IT firms in regarding India as a possible destination for setting up high-end research and development centres. This in turn caused further new entry, which had significant implications on the market structure dynamics and human capital accretion.

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Motorola

Motorola at present has operations in three cities in India, Bangalore, Hyderabad and Gurgaon. The Bangalore centre has state-of-the-art technology concentrating on high-end R&D, whereas Motorola's centre in Hyderabad has been set up in order to tap into local labour markets for lower-end software programming and coding. Motorola in Bangalore has developed strong backward linkages both with local firms and educational institutions. Motorola operates three types of projects: (i) high-end R&D projects (ii) Specific projects that bring in specialists from outside for a short period; and (iii) projects that are contracted out to Indian firms. There are about 15 Indian firms (both small and large) with which it has developed subcontractor relations. The firms are provided with training on Motorola's technology and project management.

Motorola invests significantly in universities and research institutions. Motorola has collaborations (tie-up) with fifteen colleges in Bangalore. Motorola provides the institutions with technology and tools, and training to the faculty. Furthermore, faculty members are brought in for time off in Motorola's centre. Motorola has also invested in the courses of the IITs of Bangalore and Hyderabad. Fresh and highly qualified graduates are recruited from the colleges and universities and are provided with intense in-house training. Motorola started operations in Bangalore in 1991 with 50 employees. At present, the subsidiary has about 1,300 employees, of which the majority are in software development and chip designing; mostly telecom related.

Nortel

Nortel has operations in India for developing telecom-related software. Technologically well-advanced local firms facilitate entry of MNCs through joint ventures and collaborations. Hence, Nortel entered India in 1989 through a joint R&D collaboration with large Indian firms such as TCS, Infosys, Wipro, and Silicon Automation Systems (SAS) to make use of mutual matching assets in technology, human capital, and infrastructure. The partnership became possible because Nortel could formulate nondisclosure contracts by each of its partners. In each partner's location, Nortel created infrastructure, state-of-art telecom hardware and large capacity for communications. It also invested heavily in training the employees of the Indian firms. As the partnership became successful, Nortel transferred more complex technologies to the Indian firms. The partnership benefited Nortel in reducing costs of developing telecom related software significantly, and the Indian partners in terms of transfer of latest technology and Nortel's international management practices and markets. As Nortel gained experience with the Indian market institutions through partnerships, it set up its own subsidiary in Bangalore in 2000.

This strategy is crucial for the leading international firms not because of local market size, but because the Indian industry has become a major software development centre for the global market.

Impact on Software Companies

In the initial stages, collaborations with MNCs gave local firms a brand image internationally, which ideally generated more customers. Collaboration with MNCs provided access to international markets. It provided local firms insights into the R&D and management practices of the MNCs. In partnerships, employees (the project teams) received training both in India and in the parent operation of the MNCs. The movement of skilled workers to the developed economies has exposed them to the latest technologies, ideas, and practices.

In the initial stages, collaborations with MNCs gave local firms a brand image internationally, which ideally generated more customers.

In recent years, many Indian software firms have acquired firms in the US and Europe. Joint collaborations with MNCs helped them to gain experience in the efficient management practices of the MNCs, which helped them in acquiring and managing firms abroad better. Smaller Indian firms at the lower-end of technology in India focus mostly on the domestic market in developing niche products and client services. In this case, leading MNCs such as Microsoft, Sun and Oracle have an incentive to provide free training and technology because these Indian firms are instruments to spread their platforms in the Indian market.

Indian IT industry follow group dynamics (clusters), software firms are basically concentrated in Bangalore, Chennai, Hyderabad, Pune, and Gurgaon. Several MNCs and large Indian firms have multiple development centres in all these cities to tap the locally available skilled workers. The development at the higher end of R&D work is, however, concentrated in Bangalore owing to the strong agglomeration economies of the group. Of all the centres, Bangalore has become the most dynamic high-tech cluster (Balasubramanyam & Balasubramanyam, 1999).

Analysis: Positive Impact

The paper now focuses on the effect of MNC software companies with respect to defining and understanding the industry and the issue of the link between market structures, export orientation, and human capital accretion. At present, in the Bangalore group alone, there are about 150 MNC development centres which also expanded their Indian operations substantially. Simultaneously, several Indian firms came into the market and grew rapidly, mostly through exports to the US market. The market reforms of 1991, which devalued the exchange rate and liberalized imports of technology, gave a significant boost to the exports.

The firms' export orientation relaxed the market size constraint and thereby facilitated the entry of a large number of both large and small firms. All this has contributed to a rapid increase in demand for skilled labour with both general and specialized skills. Consequently, wage rates for skilled software professional have been increasing since the mid 1990s. At present, there is intense competition among MNCs and large Indian firms for skilled professionals with experience in project development and management. This has provided strong incentives for people to acquire both the general and specialized skills. The increase in demand for education led private firms to enter the education market. Besides, there has been increasing cooperation between the governments at the national and state levels, between government and MNC software companies and between government and large Indian software companies to invest in higher education, leading to setting up of institutions such as the IITs and expanding training in government institutions such as IITs and RECs.

As understood from secondary data analysis, several leading MNCs such as TI, Motorola, Nortel, Oracle, and Adobe, are working at the high end of technology in their Indian operations. To illustrate, the Indian subsidiary Adobe India of US-based $1.2 billion Adobe System has developed Acrobat Reader for handheld devices from its concept to the final product at its R&D centre in Noida. Thus, there is a significant contribution of MNCs to human capital formation both in terms of increasing number of skilled graduates and also upgrading of skills. Except in a few cases such as Adobe and TI, most MNCs' R&D operations are in support of parents' R&D. In this case, there is generally a frequent exchange of skilled personnel between the parent's centre and the operations in India, which is an effective channel for reduction in idea gap and information spillover in a developing economy context.

Not so Favourable Implications

There are several MNCs in the ITES sector, which use cheap labour for mundane IT-enabled services. These operations employ young people with bachelor's degrees and proficient in the English language, and provide them training on the IT-enabled services and back office operations. Therefore, these operations have to be seen as mainly employment rather than technology

generating (externalities). The negative side of the increasing presence of MNCs in the India software industry is that it inhibits the movement of small local firms into high-end operations as they too are induced into lower-end activities.

Most highly skilled graduates prefer to work for well-known MNCs because of their brand name and technology or for large Indian firms, and migrate to the US (or any other developed economy). Therefore, the smaller firms including some large Indian firms, have to make do with low-end skilled manpower. Some of the local firms make employees sign a job contract. With these skills, the Indian firms can undertake software development only at the lower end of the value chain. The smaller firms become training grounds as once the workers gain enough experience, they leave to work for MNCs in India and/or to the developed countries.

There is intense competition among MNCs and large Indian firms for skilled professionals with experience in project development and management.

Several other MNCs also invest directly in the universities and engineering colleges and private training institutions such as NIIT and Aptech for developing curriculum and training teachers on the technologies to promote their platforms. For example, recently, Intel announced they would train 100,000 teachers in Internet and IT tools in India. Cisco announced the setting up of 34 regional networking academic institutions in the country. Such MNCs also provide venture capital funding for capital and technology and training to entrepreneurs in India (Dossani R., 1999).

Thus, it can be concluded, based on analysis that the entry of MNC software companies has certainly resulted in human capital accretion in the Indian software industry. Further, MNCs with backward and forward linkages in market structure dynamics have accelerated the spillover of benefits to the Indian software industry. This has enabled India to become an important player globally in this industry.

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Appendix I

List of executives with whom interviews were conducted

Sanjeev Srinivasan, Process Associate, HP India, Bangalore.

Siddharth Sinha, Software Engineer, TCS, Mumbai

Saby Zacharia, Software Engineer, Sonata Software, Pune.

Kaushal Vyyuri, Manager, IBM India, Bangalore.

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You're headed in the right direction when you realize the customer viewpoint is more important than the company viewpoint. It's more productive to learn from your customers instead of about them.

– John Romero

Feature

Managerial Effectiveness & Locus of Control

Daisy Chauhan & S.P. Chauhan

In the changing scenario of global business, it is vital for a manager to take stock of the personal attributes or a set of factors considered sine quo non to be effective in personal as well as professional life. A better understanding of one's orientation in terms of factors we attribute to the consequences of our actions/behaviour would help us to appreciate the cause-effect relationship between our actions and their outcomes. A study of Locus of Control, therefore, becomes important as it would help us to explain and predict why certain behavioural aspects attain importance to a person in achieving certain personal and organisational goals. An attempt has been made in this paper to understand the general orientation of managers from the three sectors, in terms of their perception of major factors influencing their work-life, measured in terms of locus of control and also to study its impact on role efficacy and the implication of the findings of the study. The sample consisted of 450 middle level managers drawn from various organisations located in different parts of the country. The paper also suggests some initiatives to be taken at the individual level to develop an internal orientation which is likely have a positive impact on effectiveness, both on the personal and professional front.

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Managers need to be aware of the impact of personality and perceptions on their own behaviour and the behaviour of other organisational members. This is particularly important in the face of increasing diversity in the workplace. A person's perception of the happenings in his/her life is termed locus of control. Some believe that they are masters of their own fate, others see themselves as victims of fate, believing that what happens to them is due to the influence of others, luck/chance. The first type, who believe that they have control over their own destinies are known as "internals", whereas the latter who see their lives as being controlled by outside forces, are called "externals".

According to Robbins, (2000), the overall evidence indicates that internals generally perform better in their jobs, but that conclusion should be moderated to reflect differences in jobs. Internals gather more information before making a decision, are more motivated to achieve, and make a greater attempt to control their environment. Externals, however, are more compliant and willing to follow directions. Therefore, internals do well on sophisticated tasks - which include most managerial and professional jobs - that require complex information processing and learning. In addition, internals are more suited to jobs that require initiative and independence of action. In contrast, externals should do well on jobs that are well structured and routine, and in which success depends heavily on complying with the direction of others. If this is taken as an evidence that internals are considered better holistically in their jobs, then it becomes all the more pertinent to know the impact of internal locus of control and external locus of control on role-efficacy. An attempt has, therefore, been made in this paper to understand the general orientation of managers, in terms of locus of control or their perception of major factors influencing their work life, and also to find out if there are any sectoral differences. The paper also examines the effect of locus of control on role efficacy and the implications thereof. The paper also suggests some initiatives to be taken at the in-

dividual level to enhance internal orientation so as to enhance the effectiveness.

What is Locus of Control?

Rotter (1966) defined locus of control as a generalised expectancy of perceived internal or external control of reinforcement. Individuals may show an internal or an external locus of control. The former means that positive and/or negative outcomes are attributed to own actions, and are consequently regarded as being under personal control. An external locus of control means that positive and/or negative outcomes are regarded as unrelated to own behaviour and are, therefore, beyond personal control.

Literature Survey

How Locus of Control Develops

While there is little research on the antecedents of individual differences in locus of control, that research is reviewed by Carton and Nowicki (1994). First, adults and, in particular, parents appear to influence children's development of locus of control. Carton and Nowicki (1994) found that the research supports the assumption that consistent parental use of reward and punishment as well as parental encouragement of autonomy are associated with the development of generalized internal control expectancies. Second, experiencing stressful life events, particularly if disruptive and when young, seems to be associated with a greater likelihood of external control contingencies. Third and finally, there is empirical support for the hypothesis that children with generalized internal control expectancies have parents who were more nurturing, emotionally supportive, and warm. Skinner, Zinner-Gembeck, and Connell (1998) also examined the development of perceived control in children, and found that parental involvement, family environment, teacher warmth, and academic performance help determine the development of perceived control in children.

Impact of Locus of Control

Different people credit different forces for such life events as personal successes and failures. Locus of control refers to how a person perceives the cause of life events. Someone with an internal locus of control would generally perceive himself/herself as responsible for certain occurrences (his/her actions would have a direct bearing on the result), while a person with an external locus of control would most often blame (or thank) fate, destiny, luck, society or some other force beyond his/her control. Locus of control has been found to be related to a variety of choices people make in their lives, including vocational and career decisions (Maddux, 1991). Individuals who have an internal locus of control generally are more active in trying to pursue their goals and improving their lives (Rotter, 1966). Furthermore, through ingenuity and perseverance, they often figure out ways of exercising some measure of control even in situations containing limited opportunities and many constraints (Bandura, 1990). On the other hand, individuals who believe that they have no control over the outcome of situations are likely to effect little change even in situations that provide many opportunities (Bandura, 1990).

Locus of control refers to how a person perceives the cause of life events.

Self-efficacy and Locus of Control

The literature provides considerable research linking self-efficacy and locus of control. Sherer et. al. (1982) claimed that attributional style is important for general self-efficacy. Individuals who have an internal locus of control will attribute past success to themselves, and this tendency will boost their general self-efficacy. According to Lefcourt (1982) and Rotter (1966), individuals with an external locus of control tend to doubt their personal efficacy. Self-efficacy pertains to confidence with respect to actions or behaviour, whereas locus is more concerned with confidence in being able to control outcomes (Judge et al, 1998). Both self-efficacy and locus of control are cognitive constructs and are about control (Rotter, 1966). Breed (1997) stated that both constructs are concerned with the individual's experience of the self in control of his or her own world of experience and available resources.

Job satisfaction, commitment and locus of control

Locus of control is a variable closely related to job satisfaction and commitment. Empirical evidence indicates that the tendency of "internals" to believe that they can control events and "externals" to believe that they cannot, has implications for job satisfaction (Gemmil and Heisler, 1972; Keller, 1984; Organ and Greene, 1974). Blau (1987) found locus of control to be a moderating variable in the relationship between two facets of satisfaction - promotion and pay - to organisational commitment in terms of withdrawal intentions and turnover.

Locus of Control in relation to Achievement Motivation and Risk Taking Behaviour

Some earlier studies found internality to be an im-

portant characteristic of people with high achievement motivation (McClelland, 1961) and perseverance (Franklin, 1963). It has also been found that internality generates a tendency for moderated or calculated risk taking (Wolk & DuCette, 1984).

Anxiety, Pressure and Locus of Control

Jones and Page (1986) found that individuals with an internal locus of control experience less anxiety. Tubbs (1994) confirmed that individuals with an internal locus of control handle pressure better than those with an external locus of control. Furthermore, Rahim (1996) found that individuals with an external locus of control could not handle the pressure, uncertainty and challenges of a demanding work environment.

Characteristics of Internals and Externals

Research comparing internals with externals has consistently shown that individuals with high scores on externality are less satisfied with their jobs, have higher absenteeism rates, are more alienated from the work setting, and are less involved in their jobs than are internals (Spector, 1982 and Blau, 1987). Based on literature review and their own research work and teaching experience relating to Locus of Control, Stress, Job Involvement, Motivation, and managerial obsolescence, authors have observed that internals and externals have a set of different characteristics. Some of these are given in Table 1.

Table 1: Characteristics of Internals and External

Internals	Externals
Believe that they have control over their own destinies	See themselves as victims of fate
Masters of their own fate	See their lives as being controlled by outside forces
Make a greater attempt to control their environment and are likely to be more proactive	Generally do not attempt to control their environment and are likely to be reactive or act on others' directions
Achievement oriented/highly motivated	Less motivated to achieve a goal
Gather more information before making a decision	Generally make a decision even without gathering complete information
Less compliant and generally do not like to follow directions	More compliant and willing to follow directions
Do well on sophisticated tasks - which include most managerial and professional jobs - that require complex information processing and learning	Do better in routine jobs, simple jobs
More suitable to jobs that require initiative and independence of action	Do well on jobs that are well structured and routine and in which success depends heavily on complying with the direction of others
Attribute success or failures as outcomes of one's own actions	Attribute success or failures to external forces/environment
Self Driven	External Driven
High on perseverance and do not look for immediate results	May lose interest if immediate results are not forthcoming
Generally take calculated risk	Prefer safe approach to a risky proposition
Experience less anxiety	Experience more anxiety
Handle pressure better	Find it difficult to handle the pressure, uncertainty and challenges of a demanding work environment
Tend to have higher role efficacy	Tend to have lower role efficacy comparatively
Experience less role stress	Experience high role stress
Have high interpersonal trust	Have lower interpersonal trust
More satisfied with their jobs	Less satisfied with their jobs
Less absenteeism rates	High absenteeism rates
Less alienated from the work setting and would have high job involvement	More alienated from the work setting and therefore would have low job involvement

Objectives of the Study

In view of the significant effect of Locus of Control on various facets of organisational and personal lives of individuals, the present study was undertaken with the following objectives:

- To understand the general orientation of managers from the three sectors viz., government, public and private sectors, in terms of their perception of major factors influencing their work life.
- To find out if there is any sectoral difference on internality and externality.
- To study the influence of locus of control on the role efficacy and the implication thereof.
- To suggest some initiatives to be taken at the individual level to enhance internal orientation so as to enhance effectiveness.

Sample and Methodology

The sample for the present study consists of 450 managers, by and large, middle managers from the

three sectors: government (N=107), public (N=232) and private (N =111) organizations from all over India representing different functions of management. They belonged to the 25 to 48 age group. The average age of the respondents was 38 years. Two standardised questionnaires were used for collecting the data. These were (1) Locus of Control Inventory and Role Efficacy Scale (Pareek, 1982, 1980 respectively). The Locus of Control has three dimensions namely Internal, External (Others) and External (Chance). Role Efficacy has ten dimensions: Centrality, Integration, Proactivity, Creativity, Inter-role Linkage, Helping Relationship, Superordination, Influence, Growth and Confrontation. These ten dimensions give a total score, which when converted into percentage gives the Role Efficacy Index (REI). These questionnaires were administered personally in individual as well as group settings.

Analysis of Results

Inter-sector Comparison of LOC

Analysis of the data relating to Locus of Control (LOC) revealed that out of a total sample of 450 managers, 358 (79.6%) were found to be having Internal Locus of Control, while 85 (18.9%) had a high score on External (Others) and 7 (1.5%) had a high score on External (Chance). Further, there was no significant difference among the three sectors on internality, as 86 out of 107, 177 out of 232 and 7 out of 95 had a high internal LOC score. In terms of percentages it works out to 80.4, 76.3 and 85.6 for the government, public and private sectors respectively. The details are given in Table 2.

Table 2: Details of the Sector-wise LOC Scores

Sector	Internal	External		Total
		E(O)	E(C)	
Government	86 (80.4%)	19 (17.7%)	2 (1.9%)	107
Public	177 (76.3%)	50 (21.5%)	5 (2.2%)	232
Private	95 (85.6%)	16 (14.4%)	0	111
Total	358	85	7	450

Data was also analysed to compute Mean and SD of the LOC and Role Efficacy Index (REI). The study revealed that the managers from all the three sectors scored high on internality. Further, the private sector had the maximum score of 30.62 followed by the public sector (30.00) and government sector (29.49) respectively. The inter-sectoral difference was only marginal, as can be seen from the F-value, which is 1.24. Details are given in Table 3. Research interpretation of LOC (I) scores indicates that a score of 33 and above is considered "Very High" which indicates high self confidence in a person's ability to control what happens to him/her in the organisation. Scores of 29 to 32 are considered "High" indicative of a high trust in one's ability and effort. Scores between 22 to 28 come in the "Moderate" category, which is indicative of a tendency of "Sitting on the Fence". A score between 18 and 21 is considered "Low" which indicates that the individual lacks trust and needs to examine his/her strengths by getting feedback from others. A score 17 or less was considered "Very Low" which is an indication of very little self confidence in one's effort. Such individuals will, therefore, not utilise their potential. In the present study, the scores on Internal Locus of Control were high for all the three sectors.

However, on Externality, both on the dimension of 'Others' and 'Chance' there was significant difference among the three sectors as can be seen from the F-values which were 10.17 (significant at .001) for External and 11.23 (significant at .001) for External (Chance). Details are given below in Table 3.

On Externality (Others) the scores for all the three sectors ranged from 20.40 (private) to 23.70 (public). The score of the government sector was 21.45. As per the norms, scores between 20 to 29 were considered to be "Ideal" i.e. an independent orientation coupled with a realistic dependence on others. On the other hand, scores between 30 to 34 is considered "Very High" which indicate dysfunctional dependence on significant others, and a score of 16 and below is considered to be low, indicative of a counter-dependence orientation. On Externality (Chance) the scores for all the three sectors ranged from 11.36 (private) to 14.88 (public). The score of the government sector was 14.35. Norms of Externality (Chance) indicate that the lower the score on it, the better it is. On role-efficacy, there was no significant difference among the three sectors. The government sector scored the highest i.e., 81.99 followed by the private sector, 80.66, and the public sector, 80.56.

Table 3: Inter-sectoral comparison of LOC and RE

Variable	F-Value	Govt. Sector (107)		Public Sector (232)		Private Sector (111)	
		Mean	SD	Mean	SD	Mean	SD
LOC (I)	1.24	29.49	5.40	30.00	5.49	30.62	4.95
LOC (EO)	10.17**	21.45	6.73	23.70	6,36	20.42	7.63
LOC (EC)	11.23**	14.35	6.56	14.88	6.80	11.36	5.88
REI	0.65	81.99	10.69	80.56	10.93	80.66	11.46

**Significant at .001

Correlation Analysis : Effect of LOC on Role Efficacy

The results of correlational analysis shows that role

efficacy has a significant positive correlation with LOC (I) and significant negative correlation with LOC (O) and LOC (C). Details are given in Table 4.

Table 4: Correlation between Locus of Control and Role Efficacy

Variable	LOC (I)	LOC (EO)	LOC (EC)	REI
LOC (I)	1.00**			
LOC (EO)	-.15**	1.00**		
LOC (EC)	-.23**	.61**	1.00**	
REI	.36**	-.29**	-.35**	1.00**

Implications of the Study

An internal orientation among the managers of the three sectors is a very positive indication as it showed that the managers, irrespective of the sector to which they belong, have high trust in their ability and effort. The study also revealed a positive significant correlation between Internal Locus of Control and Role Efficacy and a negative relationship between External Locus of Control, and Role Efficacy. The research indicates that people with an internal LC interpret outcomes as the result of one's own actions, and tend to accept responsibility as well as credit for their actions. In general, this attitude generates high motivation, effort, perseverance, and willingness to take risk. Internality is also related to effectiveness and adjustment. When compared to externals, internals have been reported to be more sensitive to new information, more observant, more likely to attend to cues that help resolve uncertainties (Lefcourt & Wine, 1969), and more prone to both intentional and incidental learning (Wolk & DuCette, 1984).

Evidence supports the assumption that an internal locus of control also leads to academic achievement (Crandall, Katkovsky, & Crandall, 1965; Harrison, 1968; Lessing, 1969). According to McClelland, (1961), internality was found to be an important characteristic of people with high achievement motivation. It was further reported that internal locus of control generates moderate or calculated risk taking, and one study indicated that the correlation between achievement motivation and preference for moderate risk was significant and positive among internals but almost zero among externals (Wolk & DuCette, 1984).

Conclusion and Recommendations

On the basis of the finding of the study which revealed the moderating effect of locus of control on role efficacy, it can be inferred that developing an internal orientation would help managers enhance role efficacy. Based on the results of the study it is suggested that managers should take initiatives towards developing internality.

An undesirable/unacceptable outcome can be converted into a desirable/acceptable one when an individual becomes aware of the need to change, leading to the intention to change. In the case of internals, the intention leads to ownership for action and the resultant outcome through a proactive approach. However, in the case of externals, it is likely to lead to complacency as they consider themselves helpless against external forces. The moderating effect of locus of control, as explained above, is depicted in Fig. 1.

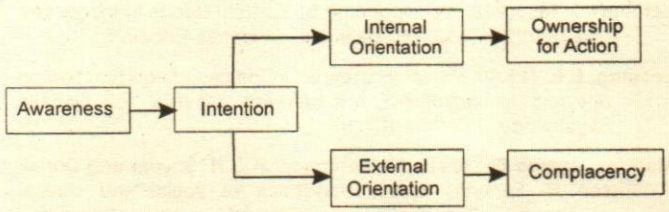

Fig. 1. Factors Influencing/Reinforcing Behaviour

To change one's locus of control, one has to do some reflection and self-examination. The first step in this direction is a thorough introspection to identify the skills, abilities, efforts, and any special talents, even the smallest ones and then try to link your achievements to some of these qualities. In case of a failure or mistake, do an objective analysis of the factors responsible for it. If there are things that can be changed in the future (inattentiveness, lack of knowledge, etc.), then make the effort to do better the next time. Only by taking ownership for one's actions or outcomes of one's decisions can one ensure better outcomes in the future.

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The worm lures the fish, not the fisherman and his tackle.

– Angler's maxim

Feature

Reverse Logistics Model in the Paper Industry

Rupesh Kumar Pati, Prem Vrat & Pradeep Kumar

The pulp and paper industry in India has tremendous growth potential, currently estimated at 8 percent per annum. But, there is a shortage of the basic raw material, wood pulp, due to limited forest cover in India. This leads to a big gap between the supply and demand, which could be minimized by recycling of the post-consumer waste paper (PCW). Reverse logistics/recycling refers to all logistic activities to collect, disassemble (or compact) and process used products and/or parts of products in order to ensure a sustainable (eco-friendly) recovery. This paper proposes a reverse logistics decision-making model in a Customer-to-Customer (C2C) supply chain that will act as a guideline for a pulp and paper mill on the option of recycling of wastepaper depending upon various constraints. The model considers impacts of paper production on energy consumed, solid waste generation, and water and air pollution. Finally, the gap analysis and the feasibility study help the management to evolve a strategy on recycling.

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Paper is the basic material used for written communication and the dissemination of information in addition to various other uses like wrapping, packaging, toweling, insulating, and photography. It is prepared from wood, rags, synthetic fibres, waste paper and natural fibres like bagasse, bamboo, flax, hemp, jute etc. Changes in the structure of the pulp and paper industry are being driven by the need both to operate as a truly international business in the global market place and for improved financial performance. The paper industry is under pressure to improve profitability by overhauling its purchasing and marketing activities and finding an alternate source of raw materials. This is required in order to reduce costs and improve efficiency. It is clear that the industry will have to move from its traditionally vertical integrated position to one that is far more aligned with its customer and customer's customer (Moore & Mitrou, 2002).

Supply Chain Management refers to the management of material suppliers, production facilities and distribution services, linked together to meet the customer's requirements consistently and reliably. Nowadays, the challenges for manufacturing firms are shifting from internal efficiency to supply chain efficiency. This supply chain can either be a forward or reverse system. Supply chain management has become a new paradigm for the industry. Both mills and suppliers have responded to this paradigm by forging integrated and long-term relationships with the ultimate aim of satisfying the customers' requirements.

Indian scenario

The paper industry is one of the key industrial sectors in India. The first paper factory was commissioned in 1832 in West Bengal. The average size of paper mills in India is about 15,000 tpa (tonne per annum) compared to 85,000 tpa in Asia and 300,000 tpa in Europe and North America. The pulp and paper industry in India

has tremendous growth potential, currently estimated at 8 per cent per annum. But, it is projected that with the existing resources, there would be shortfall between the demand and supply of 5.1 million tonnes by 2015-16 (Sharda et al, 2000). The expected supply and demand are presented in Table 1 and shown in Fig. 1.

Table 1: Expected demand/supply for paper & paperboard (in million tonnes)

Year	Demand	Supply	Shortfall
1995-96	3.28	2.41	0.87
2000-01	4.95	3.26	1.69
2005-06	6.70	4.16	2.54
2010-11	8.55	4.91	3.64
2015-16	10.88	5.81	5.07

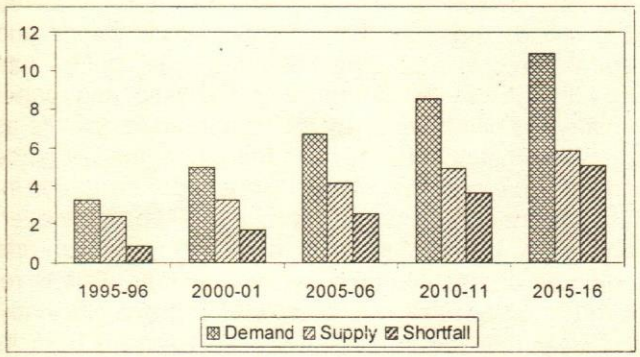

Fig. 1. Expected demand/supply for paper & paperboard (in million tones)

A variety of processes are in use in the paper industry, depending on the type of raw material and the end product desired. Among these, kraft sulphate process, semi-mechanical process and sulphite process are the most popular ones. The kraft technology alone accounts for nearly 80 per cent of the pulping in the Indian Industry. The paper mills produce a wide range of paper, which could be classified under two broad types i.e. Paper and Paperboard and Newsprint. Four major production stages in pulp and paper industry are preparation of pulp, stock preparation, sheet formation and water removal and sheet finishing.

In the present scenario of shortage of forest based fibrous raw material, problems in processing the agro residues, increasing environmental pressures, stringent discharge norms and high costs of inputs for treatment of effluents, it becomes imperative for the Indian paper industry to increase the use of wastepaper/recycled fibre for the production of paper. The recycling of wastepaper helps in sustaining the growth of the paper industry. Also, shortage of conventional raw materials such as bamboo and wood has been cited as one of the major reasons for the decline in the capacity utilization i.e. around 76 per cent (1996-97) from 99 per cent (1970-71). Hence, wastepaper stock has to be recycled so that it could be brought back to the usable form.

Recycling/reverse logistics concept

The present evolution of production systems and markets is forcing producers, distributors, and vendors to integrate their operations into a large-scale network of different services for managing materials and products, information and capital i.e. into a supply chain. Integration seems to be a new paradigm of organizing business lines and supply chain management seems to be the related organization approach that can help in managing interactions among concurrent firms as well as the markets (Villa, 2002). The area of reverse logistics is concerned with the care of products and packaging materials after they have been used. Reverse logistics refers to all logistic activities to collect, disassemble (or compact) and process used products and/or parts of products in order to ensure a sustainable (eco-friendly) recovery. According to the Council of Logistics Management, reverse logistics is defined as the process of planning and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal (Krumwiede & Sheu, 2002).

Sometimes, reverse logistics is regarded as a recycling process involving materials like aluminum cans, papers, plastics and glass. Due to the necessity that in the future products must be recyclable, a new area is emerging, which has to cover all operations necessary to return products or parts of the products for re-usage or further processing. Supply chain system of corrugated case paper is explained in Figure 2. It represents a typical case of Customer-to-Customer (C2C) reverse supply chain and is opposite to the traditional concept of forward and reverse supply chain. This C2C has two subdivisions i.e. Customer-to-Manufacturer (C2M) and Manufacturer-to-Customer (M2C). In this typical case the forward supply chain starts from the customer in the form of wastepaper return and ends with the manufacturer, who becomes the final user of the product (wastepaper). Similarly, the reverse cycle represents the movement of recycled paper from mill to the customer.

Environmental legislation and the need to make production and logistics more efficient are the main drivers for the introduction of a reverse logistics distribution concept in supply chains. Figure 3 highlights exter-

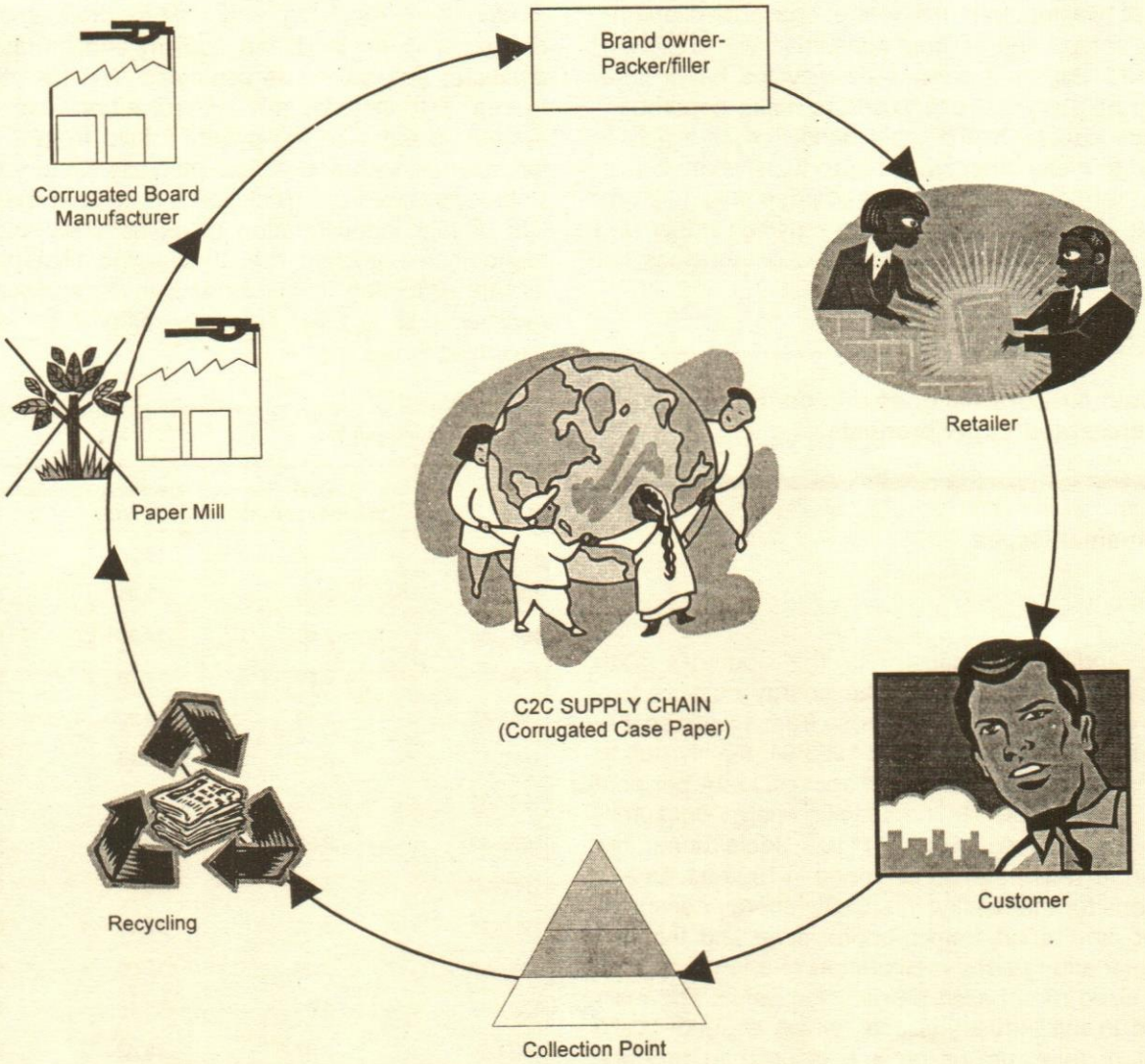

Fig. 2. Supply chain system (C2C) of corrugated case paper

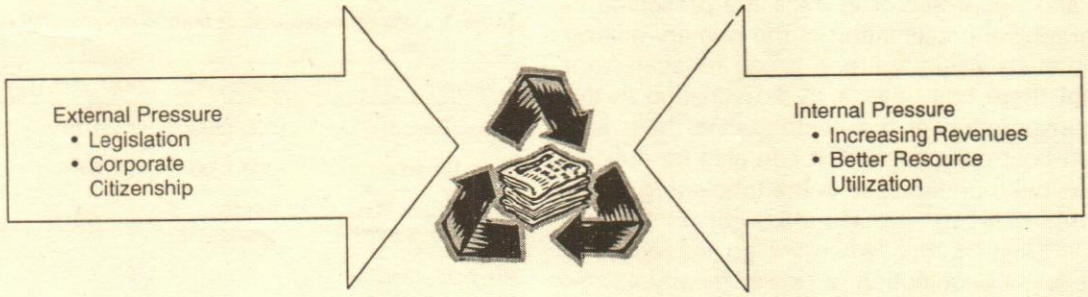

Fig. 3. External and internal pressures on a company to implement the reverse logistics

nal and internal pressures felt by companies to go for reverse logistics.

With the wastepaper recycling, we have to utilize the available capacity in the paper mill and thus reduce the imbalance between the demand and supply of paper and its products. About 40 per cent of what goes into our dumps is discarded paper products. Of the recoverable wastepaper discarded in 1990, over 85 per cent was post-consumer. As defined by the Environmental Protection Agency (EPA), 1988, recycled paper can include paper made with a minimum (50%) fibre

content of "wastepaper": mill waste, converter clippings, printer's scrap, and/or post-consumer waste (PCW). Even wood chips are considered recycled paper fibre. Recycled pulp is most often used to make paperboard or sanitary paper. On the other hand, recycled pulp is also used to make other types of products where it must be mixed with one or more types of virgin pulp. It is very difficult to differentiate between a recycled paper and one that is not; whether it's recycled or not does not determine a paper's quality.

About 40% of what goes into our dumps is discarded paper products.

Environmental issues

Energy impact

Pulp and paper industry is the country's sixth largest consumer of energy. The energy cost as percentage of manufacturing cost rose from 15 per cent in 1979-80 to about 25 per cent in 1993-94, mainly due to the rise in the cost of energy as against 12-14 per cent in the USA and Finland. The specific energy consumption has decreased from $41*10^9$ Joule/tonne (41 GJ/tonne) in 1981-82 to 35 GJ/tonne in 1993-94. One of the reasons for the decline in specific energy consumption over time, apart from modernization and technology up-gradation, is the proliferation of a large number of small sized mills based on recycled paper. The main fuel used in the industry is coal, which is about 60-70 per cent of total fuel usage and is used to produce steam, which is the most important medium of heating in pulp mills. Details of coal and electricity consumption in the pulp and paper sector in India are presented in Table 2. A graphical presentation of the primary energy consumption is shown in figure 4. It can be seen from the table that there has been a cyclic variation in the electricity consumption of the sector, while there is a steady rise in coal consumption. It can also be noticed that there has been an increase in the total energy consumption from 45.9 $*10^{12}$ Joules (45.9 PJ) in 1981-82 to 74.5 PJ in 1993-94. But, when we go for recycling there will be less consumption of power (nearly 43 per cent) and steam (nearly 72 per cent) during manufacturing. The utilities per tonne of paper with different categories of fibrous raw materials are presented in Table 3 (IPPTA, 2003).

Water pollution

The presence of caustic in black liquor results in increased dissolved solids in wastewater streams, thus rendering the receiving body unfit for drinking and if the discharge is on land, the sodium concentration contaminates the soil. It is estimated that the discharge from a 30-tonnes/day mill, without a chemical recovery system, is equal to the pollution load from a 100-tonnes/day mill with a chemical recovery system in place. Colour removal from black liquor is another major problem. A high concentration of oxygenated halogens is found in the effluent due to chlorine bleaching. Significant reduction in pollutants can be achieved when recycled pulp is used as a raw material because less bleaching is required.

Table 2: Details of energy consumption in pulp and paper industry by fuel source*

Year	Coal (million tonnes)	Electricity (100GWh)	Total Energy (PJ)
1981-82	2.14	15.25	45.9
1982-83	2.46	12.25	50.9
1983-84	2.50	14.25	52.4
1984-85	2.57	17.38	54.8
1985-86	2.83	18.22	60.0
1986-87	2.66	17.25	56.5
1987-88	2.65	15.25	55.6
1988-89	2.82	13.25	58.1
1989-90	3.31	10.74	66.4
1990-91	3.19	12.35	64.7
1991-92	3.09	12.00	62.7
1992-93	2.99	11.15	71.8
1993-94	3.07	13.62	74.5

Source: Chemprojects; #1 Conversion factor 1 kWh-3.6 MJ, 1 kg coal-18900 kJ, 1 MJ = 10^6 J

Table 3: Different categories of fibrous raw material used in production

Category	Power, kWh	Steam, Ton(T)	Water, m^3
Wood Based	1500-1600	11-14	200-250
Agro Based	1000-1200	5-6	150-200
Wastepaper Based	800-1000	3-4	20-60

Air pollution

Air pollution is considered a major problem only in the wood based pulp and paper industry and the pulping section contributes to air pollution in the form of hydrogen disulfides, mercaptans and other sulfide based gaseous fugitive emissions. The bleaching section generally poses the problem of fugitive emissions in the form of chlorine and other chloro organic compounds. The soda recovery boilers and boilers used for

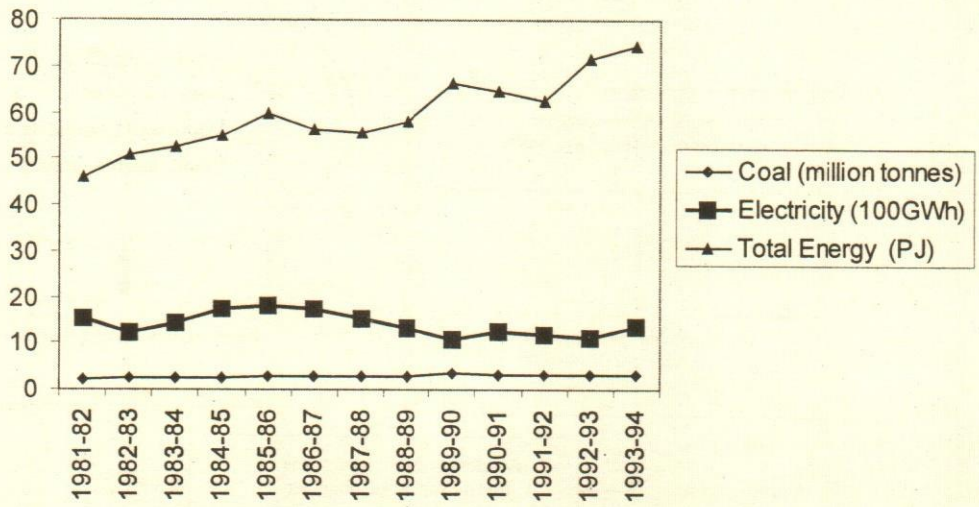

Fig. 4. Trends of energy consumption in pulp and paper industry

generating steam for use in the pulping process and for producing electricity are also sources of fugitive emissions.

Solid waste

Solid Waste is generated usually in the raw material handling and preparation sections as sludge from the effluent treatment plants and the causticizing section in the chemical recovery unit in the form of lime mud.

In India, because of all the above-mentioned issues the pulp and paper industry has been brought under the list of 17 most polluting sectors as identified by the Central Pollution Control Board (CPCB). Some of the other environmental management problems being faced by the pulp and paper industry are

- The treatment of black liquor in the effluent
- Colour removal from the effluent
- High percentage of oxygenated halogens in the effluent due to chlorine bleaching
- High biological and chemical oxygen demand of the effluent
- Contamination due to fine fibres in the effluent
- Fugitive sulfide emissions from the pulping section and emissions of volatile organic compounds
- Low boiler efficiencies in the pulping as well as paper machine sections
- Reduction in the forest cover and hence ecological imbalance and landfill problems.

And most of the above-discussed environmental impacts can be minimized to some extent when we go for use of post-consumer waste as a source for paper manufacturing. But it is not always feasible to adopt a recycling process from the management viewpoint. Hence, this paper proposes a reverse logistics decision-making model that will act as a guideline for a typical pulp and paper mill on the option of recycling of wastepaper depending upon various constraints.

Reverse logistics decision-making model

The proposed reverse logistics decision-making model for strategic decision-making is shown in figure 5. The purpose of the proposed model is to guide the pulp and paper industry to make a decision on entering into the recycling wastepaper business on the profitability and sustainability criteria.

The model depicts several key steps necessary for a mill to take in determining its current and future potential in the reverse logistics market.

I. **Identify reverse logistics suppliers (current and potential):** - The pulp and paper mill should identify and study the potentials of the existing suppliers of wastepaper (raw material for recycling). If for some reason the existing supply base is not properly utilized, it calls for a thorough analysis. Simultaneously, the mill should also look for new suppliers having the desired potential to satisfy the requirements of the mill.

II. **Identify the paper type, quality supplied and the method of collection of post-consumer waste (PCW):** - After the identification of various suppliers, investigation into the PCW paper type

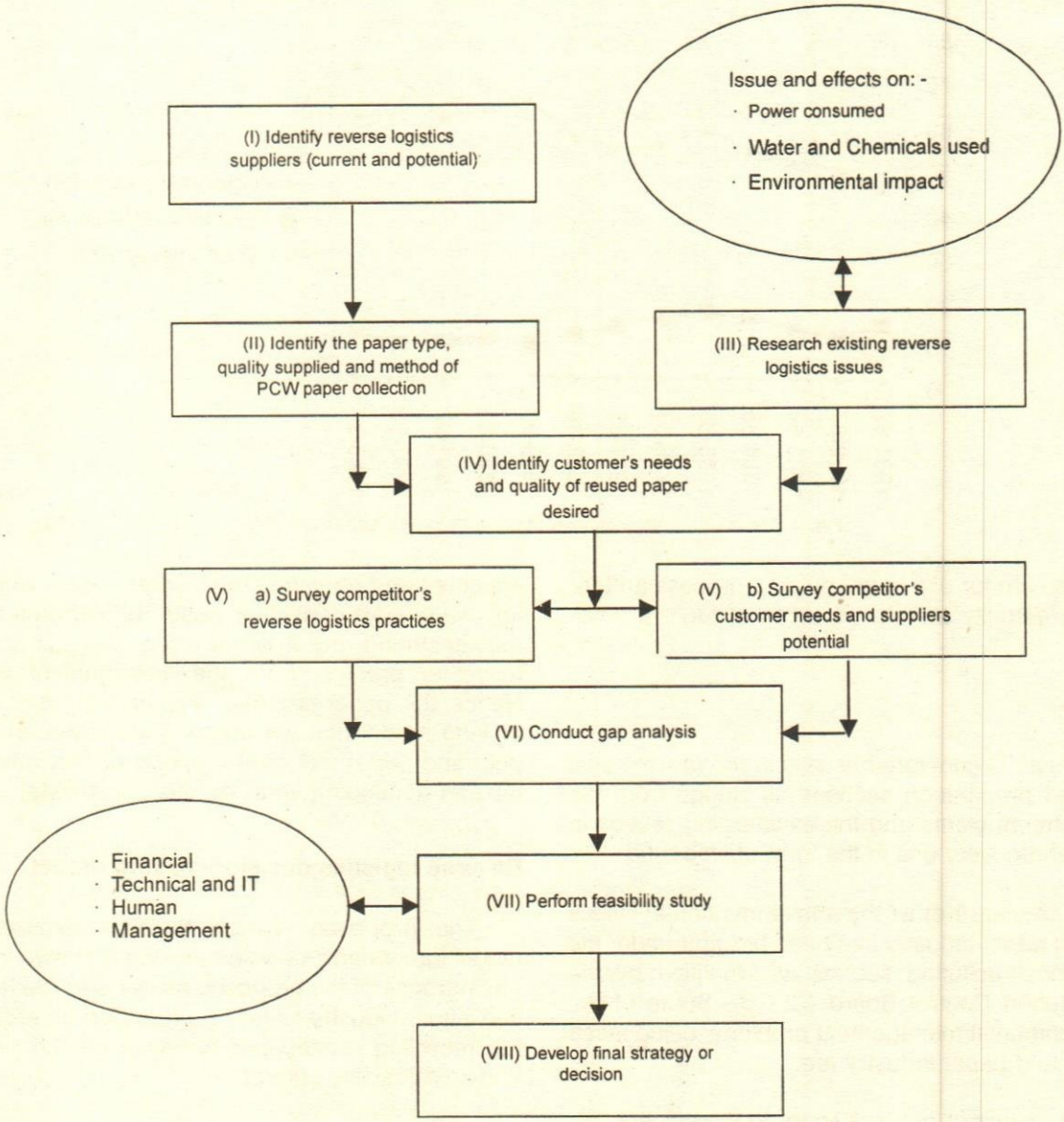

Fig. 5. Reverse logistics strategic decision-making model

and its quality should be thoroughly done. Also the method of collection of various type of PCW should be thoroughly analyzed as it affects the profitability of the entire supply chain.

III. **Existing research:** - This is the most critical step of the proposed decision-making model. A pulp and paper mill interested in entering the field of recycling/ expanding its present recycling capacity must go for a detailed market research involving literature review of current research findings in paper production from wood pulp and post-consumer waste (PCW) in conjunction with website based research. Some of the most critical issues that need to be looked into are the impacts of paper production from wood and PCW on consumption of water, power and chemicals and finally, their combined effect on the ecosystem.

IV. **Identify customer's need and quality of reused paper desired:** - Next, the mill should identify the customer's need/expectations from the product and the quality desired by customers. The knowledge gained in this stage is used later for the decision on the option of recycling.

V. **Survey competitor's reverse logistics practices, their customer and supplier:** - Key competitors of the mill should be identified to access their reverse logistics practices. Website usage and other research prove to be very effective in this step. Information about the competitor's

customer's need and competitor's supplier potential can also be gathered through interview/website services. This survey will help to gain knowledge about the strengths and weaknesses of competitors.

VI. **Conduct gap analysis:** - The knowledge obtained from step (IV) and (V) helps to compare the requirements and needs of the mill's existing/potential customers and competitor's customer along with their current reverse logistics position. The analysis will provide the mill with the information necessary to make decisions on its strategic positioning in the reverse logistics market. This analysis also provides various alternatives, which could be considered in order to minimize the gap and obtain higher supply chain profitability.

VII. **Perform feasibility study:** - The mill should utilize all the information obtained from the previous stages to conduct a feasibility study on various options resulting from the gap analysis. The feasibility study should be conducted in areas of finance, technical, information sharing, management thought and most importantly, human behaviour. The mill should compute the opportunity costs of obtaining the necessary resources and solving of the additional technical problems so as to provide an eco-friendly source of producing paper from the post-consumer waste. Feasibility should also be examined from the viewpoint of sharing information because inefficiency in this could cost the supply chain a huge loss in terms of profit due to excess inventory or lower capacity utilization. Management should also be ready to go for recycling as it has many positive impacts on the environment. Among these parameters, the most important is the feasibility from the human behavioural viewpoint. The company must also revisit its existing customers to determine if reverse logistics/recycling could fulfill their requirements. These benefits could be realized through a more planned and effective return operation gained from a fuller implementation of reverse logistics.

VIII. **Develop final strategy or decision:** - All the preceding steps discussed so far in the model are with the sole aim of reaching a final decision, "should a particular mill enter into the reverse logistics operation?" If the feasibility study indicates positively, the mill should enter the reverse logistics/recycling market with reasonable expectation of making a profit, with PCW resources. Else it should drop the recycling option.

Conclusions

The concept of reverse logistics is becoming an important segment in the Indian economy. But the use of this concept in the Indian industry in general and pulp and paper industry, in particular, is very limited. Pulp and paper has an enormous impact on the environment at different stages of the life cycle like forestry, pulp production, pulp bleaching, paper production, consumption, waste management, and transportation. In order to develop an eco-friendly environment and optimize the use of resources, recycling is the best answer. Recycled paper can reduce energy consumption, reduce both air and water pollution, conserve forest resources, reduce water consumption, and save landfill space. Thus, recycling the paper is a necessary step in resolving the very real waste management problem. There are also few limitations in recycling of the paper. The idea of using post-consumer-waste becomes improbable because of the difficulties in gathering wastepaper from scattered sources, sorting mixed papers, and recovering the fibre from many types of coated and treated papers. Another limiting factor is the lack of demand for post-consumer recycled paper products in the market.

The paper gives more emphasis on the proposed strategic reverse logistics decision-making model, which will act as a guideline for a pulp and paper mill on the option of recycling of wastepaper depending upon various constraints.

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Performance Grading of Hospitals: A Conceptual Framework

G.D. Sardana

Performance evaluation is vital for any institution. It is the first step to carry out improvements. To external customers it provides information to build up confidence in associations or dealings. Performance assessment, therefore, has to be accurate, based on facts and should be able to convey evaluation that is meaningful and rational. The exercise is not easy. Performance encompasses a wide spectrum of outcomes arising from a multitude of processes, activities and operations. There are many beneficiaries and their expectation of outcome are different and require conciliation. Service sector as such is beset with unique problems of its characteristics like inseparability, heterogeneity and intangibility. The task of segregation and identification of both the inputs and the outputs becomes difficult. Hospital as an institution is a complex organization where many medical and paramedical disciplines interact and supplement each other to generate outcome. The performance has been studied in the context of the theory of systems. Hospital has been considered to provide output from the sub-systems of (Operational) Performance, Quality and Recipient Satisfaction. Under each of the sub-systems a number of KPAs and Performance measures are proposed. Performance grading is an important tool to carry out comparison. Classification of hospitals has been proposed so that like can be compared with like.

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Medical and health care services have expanded rapidly during recent years focussing on quality and service. Increase in literacy, buying power and conscious consumer movements have intensified the demand. The IT revolution and the invasion of satellite technology have made the consumer aware of the changes taking place in developed countries and people have started demanding a similar quality service in India, also. The process of liberalization has opened up the local market, and health care systems have been under pressure to bring state of the art diagnostic technology and specialized cures. A redesigning of the health care delivery system is taking place.

The government financed or subsidized hospital system is redefining itself to organize socio-preventive medical measures or to provide basic, general or primary cures. More and more private owned clinics and hospitals are getting established as this service sector goes through a conceptual change. There is an increasing trend towards corporatisation of the medical sector and to run the same on the lines of profit earning business ventures. This has also brought in healthy competition. The investors, the hospital managements, those in the profession of care and cure and the consumers are keen to know about the performance of a hospital. This paper attempts to present a conceptual framework to evaluate the performance of hospitals, both in the private and public sectors. A grading system indicating the holistic performance of hospitals is proposed.

Performance Parameters: Some Perspectives

Performance assessment of any organization is related to its output. It evaluates the output with reference to the inputs the institution consumes. The hospital as a service sector organization is beset with many unique problems, and it is difficult to both define and determine

its output. The service sector has unique functional characteristics. Parsuraman et al. (1988) refers to these characteristics as (i) inseparability (ii) heterogeneity and (iii) intangibility. The output and the use of hospital services as input take place simultaneously so that the same become inseparable and cannot be segregated and identified separately. Pathological tests can be output as well as inputs for further treatment. A hospital is a complex organization and has outputs at different process stages such as diagnosis, clinical tests, medication, caring, etc. These outputs are of a heterogeneous nature. Outputs of care and nursing are intangibles. These cannot be quantified in normal units of measurements. Performance in terms of morbidity, mortality, recovery, health status, is subject to debate as hospital services alone cannot be held responsible for the same. As a consequence, most of the approaches to evaluate or assess the performance of a hospital have relied on surrogate measures or indirect parameters. These approaches can be classified under four categories as given below:

Financial Parameters

Under this approach, a hospital is considered a commercial venture which is prompted to earn returns and provide value to the investors. It is rationalized that a performing hospital, like a business unit, will attract more patients as customers, and thus will generate more revenue. As more and more hospitals get commercialized, this approach is taking root. Balance Sheet and the Profit & Loss Account are the main sources of the financial results, which are interpreted as performance. An enormous literature exists on financial measures. Income, profits, net worth, dividends declared, creation of assets and generation of reserves are some of the prominent measures. As a hospital is generally an expense centre, cost accountants advise that the performance can also be measured by comparing actual expense with benchmarks. Derived ratios such as return on investment or capital employed, growth in income or profits over the previous year, expenses as related to income, are a few more performance parameters. Other measures include EVA, MVA, residual income, economic value of assets, etc. Higher values or ratios signify better performance.

Financial measures of performance can prove to be a good yardstick of evaluation, provided all the outputs and inputs can be measured in monetary terms. This is also the basic premise of a profit centre concept. However, a hospital is a different type of an organization. Most of the input is in the form of knowledge workers like doctors, technicians and other specialists who cannot be converted into monetary units. The measurement of output in monetary units is even more difficult. It is not possible to quantify recovery of health in money. The approach does not take into account the expectations of the customers. The financial measures do not convey either the status of cure or care. Revenue generation can exist for reasons not related to restoration of health. Income or profits may also exist for reasons of excellent publicity and public relations by the hospital management. Very often, like a commercial venture, the name of the hospital attracts the patients. Hospitals are also known to build up brands.

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Use of Audits

Hospitals and other institutes related to health care sometimes use checklists to carry out audits of various functional areas. Normally organized hospitals have an Audit Committee, which comprises of senior consultants and members of management. This committee carries out the audit of morbidity cases as also of patients who remain admitted in the hospital for a longer duration. The exercise calls for a systematic and critical evaluation of the quality of medical care in retrospect through an analysis of the medical records of the hospital and the systems followed. Audit formats prepared in advance are also used to carry out audit of various service areas and laboratories. Trained persons, who have the knowledge of the functional areas, carry out the audit. Openness and transparency are prerequisites for this approach.

As the audit concerns the inside records and systems of the hospital, the management would be reluctant to make the audit reports public. This approach has, therefore limited application and is used mostly for internal management controls. The audit is found useful for assessment of various hospital infrastructure services. The audit approach has usefulness limited to such areas as medical training or quality of medical care. It is difficult to extend it to areas of cure or diagnosis, which are more technical in nature. A major drawback of this system is that the members of the audit committee are all part of the organization, and therefore, there is a tendency to be biased as well as to protect colleagues. The audit checklist is likely to vary from one hospital to another, and thus cannot be used as a standard measure.

Quality Indices

This approach concentrates on caring elements on

the premise that it is difficult to sit on judgement of clinical matters, as these constitute highly technical subjects. Quality in a hospital is assessed in various dimensions of service under this approach. Patient, as recipient, is the focus of service.

Several authors have proposed a number of models. Donabedian's (1980) model on structure/process/outcome provides a comprehensive typology of quality dimension. Uma Chandrasekaran and M. Basheer Ahmed Khan (2000) have presented a matrix detailing the interaction of structure, process and outcome with the technical, interpersonal and environmental physical elements. Lehtinan and Laitamaki (1983) have proposed three dimensions of quality of service as (i) Institutional quality (image) (ii) Physical quality (surroundings, equipment, etc.) and (iii) Interactive quality (interaction between the patient and the medical contact person) representing behavioural aspects of services rendered to patients.

IS 13808 (Part 3) has listed guidelines for quality management procedures for wards, nursing services, the operation theatre and the labour room. It has recommended that a fixed number of patients cases, selected at random, be evaluated by a review of records on regular intervals. Large organized hospitals generally develop their own norms for providing this type of service in wards.

The approach suffers from many limitations. Foremost, it is confined to only one aspect of hospitalization. The major function, that is restoration of health, is not covered. The exercise is once again only an internal evaluation of service in limited areas and compares the actual status of defined provisions with predetermined norms. The results are not open to the public. Besides, it is known that hospitals create different type of wards to suit the pockets of patients. Some hospitals even permit hiring of private nurses for care during stay. The system implies that performance is a direct variable of the paying capacity of the patients in the same premises. However, the yardstick of performance cannot be applied in other than one way in one premise.

Performance is a direct variable of the paying capacity of the patients in the same premises.

Patient Satisfaction

This parameter has been very widely used and has been recommended on the grounds that ultimately it is the satisfaction level which propels a patient to choose the same hospital next time and it is patient satisfaction which becomes a certificate of approval for patients to be. SERVQUAL, as developed by Parasuraman et al. (1988), has been modified and adopted by many researchers to evaluate health care systems. Uma Chandrasekaran and M. Basheer Ahmed Khan (2000) refer to studies, which have used interviews of patients and physicians to arrive at an evaluation of satisfaction. A number of dimensions have been suggested that influence satisfaction. These include physician care, nursing care, location of the hospital, presence of support staff, convenient visiting hours, expense budgets, availability of emergency aid, etc.

Both the earlier approaches, that is the Audit and the Quality Indices as well as the approach of assessing Patient Satisfaction, lay emphasis on the caring aspect of hospital service. The cure function has not been considered. Whereas in the first two approaches the exercise is meant to be for internal controls, the third approach involves patients in assessment. This can be considered a redeeming feature.

A major inadequacy in approaches related to patient satisfaction lies in the fact that patients judge the performance of neither the clinical cure nor the skills or technology employed but reach conclusions on the basis of behavioural attitudes and communication skills of the doctors and the attending staff. The patients already under tension, stress and worries of ill health get highly relieved by empathy shown to them and this gets projected as a high degree of patient satisfaction and, therefore, as good performance by the hospital. Under any rational discussion, care cannot be considered as the main function of a hospital.

Performance Evaluation of a Hospital

The service sector is characterized by features, which are unique and not shared in a major way with the other sectors of the economy. The service sector is predominantly customer centred. Response to customers, service to customers and customer satisfaction are keywords in any vocabulary related to performance assessment. Customer relations, information dissemination and customer sensitization are major achievement objectives. Besides, output in service emanates from knowledge, expertise, skills and technology. These require attributes of teamwork, coordination and interpersonal relationships. Many of the outputs from the service sector can be of intangible types, difficult to quantify on normal scales of measurement. In terms of organizational activity, service, as a functional component, can be both a product and a resource.

Quality constitutes an important ingredient of output. It is present in various dimensions. Very often, quality becomes synonymous with outputs. For customers who are not familiar with specialized knowledge or technology, quality becomes the major attribute of performance. In a health service setup, quality and service take predominance. Even a fully cured patient cannot forget the experience of unending queues, long waits for the arrival of doctors, rude nurses, the indifferent attitude of attendants and callous ward boys. Memories of stinking corridors, dirty beds and lack of empathy all around when one visits to seek care linger on. The cure, the medicines administered or the diagnosis take a back seat in contrast to the quality of the care and services. The reverse is equally true. Many hospitals are known to attract patients on the grounds of hospitality.

Many hospitals are known to attract patients on the grounds of hospitality.

An all comprehensive model of hospital performance evaluation should incorporate measures of performance of functions of service, quality, customer satisfaction, besides, performance against cure dimensions of diagnosis, clinical examination, therapeutic and rehabilitation services. The performance should incorporate both the cure and the care aspects. A balanced measure of performance should project a holistic assessment of the hospital, covering areas of operational performance, maintaining quality of both care and cure to the satisfaction of the patients. Parameters of operational performance are based on the objectives of the organizations and refer to the basic performance objectives, which the organization is called upon to deliver. Quality refers to the attributes of the cure and care delivered or the functions carried out. The recipient satisfaction concerns the degree of achievement of objectives as perceived by different users of the service. A holistic measure of the performance should, therefore, include these dimensions. A comprehensive model on performance measurement concerns itself with the evaluation of operations, quality of operations and the satisfaction received from the performance.

PQR - The Performance Matrix

With increasing emphasis on quality and customer satisfaction, the approach to assess the performance of an organization, in general, has undergone a vast change. The change is all the more evident in the case of service sector organizations, where quality and satisfying values take precedence over other parameters. The concept of performance takes a broader shape. A hospital is expected to carry out operational functions of cure, maintaining quality in both cure and care to the satisfaction of the patients. Under the proposed PQR matrix of performance evaluation, an organization is considered to deploy all of its input resources to deliver output which can be expressed as a matrix of PQR, representing,

P - Performance (Operational)

Q - Quality

R - Recipient Satisfaction

P, Q and R have been considered as systems. Each of these systems will comprise sub-systems and Key Performance Areas (KPAs). The sub- systems, the KPAs and the measures need not be equal in importance, priorities or ratings. The following sections elaborate upon the sub-systems and KPAs under each component of the matrix.

Sub-systems and KPAs under 'P'

The operational performance of a hospital has several dimensions. The objectives and the goals of the hospital determine the areas. The performance encompasses financial as well as non-financial measures. Financial performance refers to earnings, profit, growth in income, return on capital employed, EVA, creation of assets, dividends paid, etc. The financial performance parameters have been excluded from this section but included under Promoter Satisfaction under 'R'. Non-financial sub-systems, relevant to operational performance, are included under P and discussed as given below:

Functional Performance

The basic function of a hospital is to cure a patient of his/her disease, make him/her healthy with restoration of proper functioning of his/her organs. The patient indeed looks forward to proper care but the cure always gets a priority over care. The principal functions of a hospital are, therefore, in the areas of a proper diagnosis of the ailments and a course of treatment so as to restore the health of the patient without creating any side effects. The earliest it is carried out, the more efficient is the hospital. The functional programme in a hospital is dependent on its size and character. IS 12433 details basic requirements for hospital planning. It is recommended that a 30 bedded hospital should have the medical and paramedical disciplines of anaesthesiology, community medicine, emergency medicine,

general medicine, general surgery, obstetric and gynaecology, paediatrics, radio diagnosis, ecg technology, ophthalmology, X-ray imaging, ultrasound imaging, drugs and pharmacy. Besides these, there is a provision for optional disciplines of dentistry, pathology and dietetics and therapeutics. Larger hospitals will have more disciplines added. Speciality hospitals are devoted to the cure of specific diseases, and therefore, their programmes have to be different and are designed to meet the specific requirements of the specific interventions. Along with cure, care also becomes an important constituent of the hospital function. Care supplements the cure. Sometimes the care element can take precedence over the cure. This happens specifically in long residential treatment when the patient has to be confined to bed out of necessities or in case of postoperative interventions. Functional performance constitutes the most important area. Performance is contributed by various medical and paramedical disciplines in curing the patient, and by the nursing staff in extending care. It is proposed to be assessed therefore, under the sub-systems of Medical disciplines, Paramedical disciplines, Nursing and Allied Services. The performance encompasses clinical consultations, diagnostics, medical treatment, other medical interventions and care.

Resource Management

A performing hospital aims at optimal use of its resources. Low utilization will increase operating costs, which will have to be passed on to customers. A high utilization, on the other hand, may result in denial of timely availability of aids to patients in emergency. Besides the all-important resources of doctors and the paramedical staff, a hospital has expensive diagnostic equipment, laboratories and the operation theatres. Several types of wards constitute another asset. A performing hospital aims at balancing the needs without creating either surplus or scarcity of resources. Funds constitute another resource, which can outweigh the importance of other resources. Finances are required for both short term needs as well as long term needs. Another important resource in health care service is time. Administrative delays in denial of cure or care can lead to mortality or prolonging of misery. Proper use of manpower is another component of time. It should be expected that medical manpower does not spend too much time in paper work or in travel. Three KPAs have been recommended under this sub-system: Manpower that includes professional and auxiliary health personnel, Infrastructure and Finance.

Management Practices

This sub-system represents corporate governance, which provides direction, sets the goals and lays down norms to achieve performance. It directs the sub-systems and outlines the values and work practices against which the hospital administration is required to conduct itself in its day to day affairs as well as in dealing with its customers. A hospital as an institution is a sensitive organization where expertise and knowledge play an important role. HR practices, work values and interactions between the specialists carry high significance. A high degree of team spirit and a cordial atmosphere, sensitive to the needs of the patients, is to be encouraged.

The image of a hospital plays a significant role in attracting new patients. The image is not confined to the availability of capable medical staff and the latest diagnostic equipment. It also covers such dimensions as empathy, values, practices and attitudes towards patients. Often a hospital, although well equipped in both cure and care, is not in a position to attract patients because of differing public perceptions. Management practices set the tone and provide directions to all staff to work as a team and in a coherent manner to create the right perception. Management practices, therefore, cover a large area. The following KPAs are recommended: Vision & Goals, Mechanism, HR Practices and Customer Relations Management Practices. The Management Practices constitute the foundations for the organization. Healthier the practices, the stronger shall be the base for the growth of the organization.

Management practices set the tone and provide directions to all staff to work as a team.

Sub-Systems and KPAs under Q

Many consider quality as the real performance of the health services. Quality carries varied meanings. It can be described as meeting the expectations of patients in terms of restoration of health without side effects of medication, costs and period of hospitalization. Like in other service sector economies, health services are also largely dependent on the availability of knowledge, skills and expertise. Thus, education and qualification of doctors, their exposure and record of patients treated become one yardstick of quality. It is not unknown that quite a number of hospitals enjoy repute because of association with some reputed doctors having made their mark in the profession. Technology is another factor, which accounts for quality in performance. Health services have become highly technology oriented. Diagnostic practices and procedural functions in clinics and surgery are dependent on

modern instruments, tools and laboratory equipment. A hospital that is equipped with the latest diagnostic facilities scores. It is equally important that the concept of quality is accepted and practiced in all the functional areas of a hospital. The sub-systems and the KPAs under 'Q' have been studied under the three sub-systems of (i) Functional Quality (ii) Technical Quality and (iii) Process Quality.

Functional Quality

This relates to the quality of the performance that is carried out. The functions of a hospital, the cure and the care are mainly delivered by appropriate treatment skills, expertise and know-how as possessed and practised by the medical and the paramedical staff. Medical technology has come to play a significant role. Medical technology is represented in the form of knowledge, know-how, procedures, provisions for CME (Continued Medical Education), diagnostic, analytical and treatment facilities. The functional quality therefore gets related to the quality of the medical staff for curing and caring; technology used, equipment put to use and maintenance of facilities installed. State of the art facilities and diagnostic equipment are other important ingredients of functional quality. Hospitals realize that a commitment to the use of latest medical technology, sustaining high standards of treatment and continued professional development are vital to gain the trust of patients. A hospital should have the ability to learn faster than the competition to retain its competitive advantage. Quality of doctors, Quality of auxiliary staff, Quality of paramedical staff, Quality of cure and Quality of care are recommended as KPAs.

Technical Quality

Technical quality refers to quality of what is delivered. It projects the achievement of attributes of the services provided. Comparison is sought with technical parameters or specification laid in advance or with chosen benchmarks. Technical quality of cure is sought to be evaluated by assessing the correctness of the various diagnostic reports as prepared by the technology centres. Mainly these are the pathological services, radio diagnostics, and ECG and Ultrasound labs. In areas of diagnosis, the correctness of investigations and laboratory tests provides a proper yardstick of assessment. The know-how as well as the technology of the lab determines the correctness of investigations. Whereas the know-how aspects have been covered under the Functional quality, the technology aspects of the equipment used and the rate of success of the reports are covered under Technical quality.

Process Quality

This focuses on the quality for managing the means to achieve performance or the outcome. A hospital is a complex system. It incorporates personnel drawn from various disciplines - medical, paramedical, engineering, administration - who are required to perform as a coordinated team. It has diverse support service infrastructure in areas of dietary service, sanitation, supplies, laundry, housekeeping and laboratories, which play a major role towards care and cure. Management of values such as customer focus, convenient procedures and performance orientation go a long way to build process quality. Besides, the hospital ambience incorporating sanitation, cleanliness and patient friendly environment contributes to the process quality. IT is yet another area that makes an impact on the process through easy availability of information and data. The following three KPAs are included: Customer focus, Ambience and Support services. The last of the areas is large and determines the process quality in a major way. Support services include, Supply System (stores), Engg. Services (power, water, gas, etc.), Dietary Services (kitchen, canteen), Laundry services and Pharmacy.

Management of values such as customer focus, convenient procedures and performance orientation go a long way to build process quality.

Sub-Systems and KPAs under R

Like other systems, a hospital has a number of recipients of benefits. Besides patients and their family members, there are several others who are the beneficiaries of the organization. The investors have different expectations. Within the organization, the operational areas become internal customers to each other. Society constitutes one more recipient with its own expectations.

A hospital, as an organization, can be considered to have four categories of recipients of benefits: (i) the Promoters, who have invested or own the hospital (ii) the Customers, who as patients approach to obtain cure, care and medical advice (iii) the Employees, who as doctors, paramedical staff, technicians, ward boys or administrative staff carry out the various assignments and (iv) the Society, the neighbourhood or the state or the general public at large. The areas of satisfaction and the level of satisfaction these obtain are based on per-

ceptions they carry about their association with the organization. These expectations or the levels of satisfaction can change with the objectives of the hospital, its size, its structure and location. A rural hospital funded by a social welfare trust will generate different satisfying values as compared to a speciality hospital catering to elite customers. The following sections examine the various KPAs of satisfaction for each category of beneficiaries.

Promoter Satisfaction

For an investor, including shareholders, a hospital represents yet another business opportunity to expect adequate compensation in the form of regular returns on his/her investment. Besides, the investor as a promoter expects that his/her investment should be safeguarded and that it grows in future years. This is true of a vast majority of health care systems, which are run either as corporate entities or by individual entrepreneurs including medical practitioners. Even the state is increasingly redefining its role towards state funded hospitals that the hospitals, should be self-supportive and not depend on state aids. That is, the hospitals should generate income to sustain their existence. For a miniscule population of hospitals run by trusts or other welfare philanthropists, the social objective to serve mankind becomes prominent. The promoter satisfaction in such instances lies in parameters, which emphasize social objectives. The weightage factors of the KPAs under the Promoter Satisfaction should take into account the objectives for setting up the hospital.

The state is increasingly redefining its role towards state funded hospitals.

As in any corporate economic activity, revenue generation, profitability and returns become the major areas for achievement. For non-profit oriented hospitals, the areas of revenue generation from aids, subsidies, state grants and donations also constitute an activity. The revenue generated requires to be utilized in an efficient manner. Growth of assets, revenue and profits are other areas of performance providing satisfaction to the promoters in profit centred outfits.

Promoter Satisfaction can be studied in four distinct KPAs:

Financial returns in the current period; Growth, which is related to strategic planning; Funds management and Societal Image.

Employee Satisfaction

Both cure and care in a hospital are largely dependent on the dedication of the doctors and paramedical staff. In this respect, a hospital represents a work domain of knowledge workers and intellectuals. This category of professionals are short in supply, high in demand and competing hospitals go all out to retain the services of their employees and provide total satisfaction to them in their jobs.

Salary, compensation and perks no doubt play an important role. However, job satisfaction is an important ingredient. Freedom at work, responsibilities appropriate to exposure, opportunities to carry out innovation and experimentation, enrichment of jobs, adds to job satisfaction. Right work practices enhance job satisfaction. Encouragement to team work, participation in decision making, particularly in choice of equipment, recognition of performance lead to higher degree of satisfaction. Emphasis on accuracy, attention, transparency and adherence to schedules are other positive work practices. Opportunities to grow and to achieve professional development are other areas that make the knowledge worker satisfied and motivated.

Medical technology advances at a fast rate. In developed economies doctors require to upgrade their qualifications every few years before they are permitted to continue their medical practices. Hospital doctors require CME (Continued Medical Education) in the form of training at advanced medical institutes or by attending seminars or through workshop practices under skilled physicians. This is yet another area that can add to satisfaction.

In developed economies doctors require to upgrade their qualifications every few years to continue their medical practices.

Three KPAs are considered: Work Practices and Values, Compensation and Growth Opportunities.

Customer Satisfaction

Patients and their families constitute the customers. Patient satisfaction lies in his/her expectations of fast recovery and in least expenses incurred. While undergoing treatment, patient satisfaction is more determined by the care that he/she receives as against the cure. A patient is neither qualified in medical science practices

nor is educated enough to sit on judgement of clinical management, diagnostic expertise, technology of the equipment used, skills of examination and procedures of treatment. He/she therefore, weighs his/her satisfaction largely on the scale of care dimension and his/her perception of physical, mental and emotional peace he/she receives through interaction, communication and behaviour of the hospital staff and the operating systems.

A patient expects the hospitals to deliver as much of medical care as has been promised to him/her through various sources of information such as publicity, media, bulletins, etc. He/she expects availability of attending doctors, specialists or other technicians the hospital has so promised. Convenient appointment systems, visiting hours and good ambience add to the credibility. Availability of medical equipment in working order, medicines, test facilities increase the satisfaction level. Access to information, prompt response, technical competence to answer queries, capable guidance, are some of the satisfaction areas which heighten responsiveness. Empathy counts a lot for a sick person. Personal attention from the hospital staff, honesty in interaction, compassion in dealings and an attitude of cordial behaviour keeps the patient satisfied that he/she is under the charge of competent hands who understand his/her needs and who are emotionally involved to provide him relief from suffering.

Another class of customers comprises the attendant relations or friends who bring the patient to the hospital for treatment. Besides expectations of immediate attention from the staff and speedy completion of formalities, these customers look for facilities of comfortable sitting place, availability of light, water and air till the patient is attended to by the doctors. Inconvenience faced by this class of customers deters them from the next visit to the hospital even if they happen to be patients this time.

These aspects are covered under the four KPAs of Credibility, Availability, Responsiveness and Empathy.

Societal Satisfaction

The size or the magnitude of society laying claims of societal benefits varies with the size and the location of the hospital. For a small hospital, neighbourhood residential area may constitute the entire society. For a speciality hospital, the society may take the shape of population over the town or the region or the country. In these cases, the hospital comes to represent the aspirations of the community to provide cures which cannot be provided by average health centres.

Foremost, the society takes pride in availability of cure and care facilities so that the citizens do not have to run to distant locations. Time is one component, which is not available to a patient even at a price. Emergencies make the situations more pathetic. One wishes immediate availability of medical attention. A well-equipped hospital with state of the art technology is a boon to society. A well-maintained infrastructure, appropriate ambience, cleanliness and efficiency are other desired features society expects in a hospital.

The hospital as an organization is a corporate citizen. Its main goal should be to create value for the society as a whole and not for just a few patients. A hospital is expected to extend its horizon to care for the long-term needs of the society by focussing on the particular needs of the society where it is placed. Society expects that the hospital will take care of social issues such as spread of health care practices, preventive medication measures such as immunization, vaccination, holding of public seminars to spread education, etc.

Society expects that the hospital will take care of social issues such as spread of health care practices, preventive medication measures such as immunization, vaccination.

A hospital generates bio-wastes, which can be a hazard to health. It is expected that the disposal be in a scientific way without creation of any problem related to pollution. If the hospital procedure leads to degradation of the environment or spread of hospital bred infections, it cannot be counted as a service to society. Quality that focuses only on expectations of a few rich patients at the cost of the other patients who cannot afford to pay or the society cannot be real quality.

Another important prerequisite for a hospital to become a useful corporate citizen lies in its adoption of the ethics of good governance. Management practices have to be based on transparency, accountability, honesty, integrity and responsibility. A patient is at the mercy of the medical staff. He/she lacks medical knowledge and is devoid of skills to argue his/her case. He/she accepts whatever is administered to him/her. Good governance calls for an attitude of compassion and dignified behaviour towards him/her. It should spell out its values and make transparent its procedures by which it manages the cure and the care. A patient has much at stake when he/she registers at a hospital. He/she desires to know the facilities and arrangements of cure and care available.

There is a strong need for transparency and honesty of procedures carried out.

It is proposed to study this sub-system under the three KPAs of Governance, Social Cause and Values.

The various Sub-Systems, KPAs and the Measures under P, Q, and R have been listed in Table 1, 2 and 3, respectively.

Instrument of Grading

Having identified various sub-systems and the KPAs, the measures under each of the KPAs are required to be evaluated on a scale. The evaluation once carried out is to be integrated so as to provide an index of performance for each of the KPAs. Similarly, an integrated index is required for the sub-system as well as one index for the hospital as a system that projects holistic performance. The evaluation and the integration comprise several steps that are discussed as under

The Priorities

Five and three sub-systems under 'P' and 'Q' each and four Sub-systems under 'R' have been considered. Each of the Sub-systems comprise a number of KPAs. Each of the KPAs has several Measures of performance. The Sub-systems, KPAs and the Measures are neither equal in priority nor equal in importance. Each of the Sub-systems is to be assigned a weightage to project relative importance. Similarly, each of the KPAs and the Measures is to be assigned weightage to project relative priority. The weightages can be arrived at through several methods. Prem Vrat et al (1998) has detailed a methodology termed as pairwise comparison approach that can be carried out on a scale 0-1. Pairwise comparison approach has its basis in behavioural sciences and is an established and tested methodology. Under this approach, an analyzer or a group of analysts are required to choose the more important of the two alternatives and decide the degree of importance on the scale.

Alternatively, under the proposed system of gradation of hospitals this exercise can be carried out by the Audit Committee and standard weightages developed for a category of hospitals. The priorities and the weightages are determined with reference to several parameters. The policy objectives of a hospital provide the guiding principles. It is known, for example, that hospitals of all types, as run by the state/public bodies, are not being run for profit motives. Health care centres at village/sub-center levels are established with a long-term objective to achieve aims of propagation of health care education and prevention of diseases. Similarly, trust hospitals are run for charity objectives. It would be wrong to provide higher weightages to financial performance objectives. Even satisfaction objectives take a back seat in the absence of profits. The principle of satisfaction lies in dictum of –value for money. Secondly, the fixing of weightages is related to the size of the hospital and the infrastructure installed. A speciality hospital has stress on high-risk medical interventions and resource allocations for innovations, experimentation and research. A part of performance is linked to strategic plans. Routine hospitals such as first referral hospitals under the state are not burdened with these expectations. Therefore, the two categories of hospitals will have different weightages for the measures. For easy comparison, certain standardization can be brought about by creation of like categories of hospitals and deciding on common weightages.

Assessment of Measures

Each of the measures is required to be assessed. The responses can be expressed in terms of percentage achieved of benchmarks. These benchmarks can be internal or external. The internal benchmarks are predetermined and are based on the capabilities to grow or achieve higher degree of excellence in all operational areas or a sheer ambition to reach top positions. Usually this approach is resorted to by organizations that have reached stages when competitors are left behind. These organizations set benchmarks for others. External benchmarks provide a second approach where the organization compares its performance with what others have achieved. This approach is recommended under the instrument of grading as the instrument proposes to compare like hospitals.

The internal benchmarks are predetermined and are based on the capabilities to grow or achieve higher degree of excellence in all operational areas.

Except for financial measures that are quantitative in nature, and, therefore, can be measured in absolute numbers or in terms of ratios or percentages of benchmarks, most of the other measures are qualitative in nature. These are to be assessed by experts, as in case of cure parameters or technology, Employees or the society, best assess the satisfaction parameters. This assessment can be carried out by administering a structured questionnaire to as large a population as possible. As absolute numbers are not possible, it is proposed to carry out this exercise under grades.

Table 1: Sub-system, KPAs and Measures under 'P' (Weightage-0.60)

Sub System	weightage	KPAs	weightage	Measures	weightage	Evaluation 1 to 5
Medical Disciplines	0.40	Anaesthesiology	0.10	(a) Interventions carried out	0.50	3
				(b) Intervention success	0.50	3
		Emergency medicine	0.10	(a) Patient turnover	0.50	3
				(b) Patient recovery	0.50	3
		General medicine	0.10	(a) Patient turnover	0.50	3
				(b) Patient recovery	0.50	3
		General surgery	0.10	(a) OT interventions	0.50	3
				(b) Intervention success	0.50	3
		Obstetric and gynaecology	0.10	(a) Patient turnover	0.50	4
				(b) Intervention success	0.50	3
		Paediatrics	0.10	(a) Patient turnover	0.50	4
				(b) Intervention success	0.50	3
		Dentistry	0.10	(a) Patient turnover	0.50	4
				(b) Intervention success	0.50	3
		Ophthalmology	0.10	(a) Patient turnover	0.50	3
				(b) Intervention success	0.50	3
		Pathology, Labs.	0.10	(a) Tests carried out	0.50	3
				(b) Success in diagnosis	0.50	3
		Radio diagnosis	0.10	(a) Diagnosis carried	0.50	3
				(b) Success in diagnosis	0.50	2
Paramedical Disciplines	0.15	Ultarsound,X-ray	0.25	(a) Diagnosis carried	0.50	3
				(b) Success in diagnosis	0.50	2
		ECG technology	0.25	(a) Interventions	0.50	3
				(b) Success rate	0.50	2
		Operation theatre	0.25	(a) Interventions	0.50	3
				(b) Success rate	0.50	2
		Drugs and pharmacy	0.25	(a) Number of formulations	0.50	3
				(b) Success rate	0.50	2
Nursing and Allied Services	0.15	Nursing services	0.20	(a) Status of Service	0.50	3
				(b) Time management	0.50	2
		Dietetics and Catering	0.20	(a) Status of Service	0.50	3
				(b) Hygienic preparations	0.50	2
		(a) Laundry	0.20	(a) Cleanliness	0.50	3
				(b) Status of service	0.50	2
		Sterilization and disinfecting technology	0.20	(a) Status of service	0.50	2
				(b) Time management	0.50	2
		Medical records	0.20	(a) Easy availability	0.50	3
				(b) Maintenance status	0.50	2
Resource Management	0.15	Human resource management	0.25	(a) Adequacy of doctors (doctor-patient ratio)	0.50	3
				(b) Adequacy of auxiliary staff (doctor-nurse ratio)	0.50	2
		Infrastructure management	0.25	(a) Adequacy of equipment and facilities	0.50	2
				(b) Working order status	0.50	3
		Funds management	0.25	(a) Adequacy of working capital	0.50	3
				(b) Stability of funds, sources	0.50	5
		Time management	0.25	(a) Availability of staff as per schedule	0.50	3
				(b) Administering service as per schedule	0.50	3

(Contd.)

Table 1: Sub-system, KPAs and Measures under 'P'(Weightage-0.60) *(Contd.)*

Sub System	weightage	KPAs	weightage	Measures	weightage	Evaluation 1 to 5
Management Practices	0.15	Vision and Goals	0.25	(a) Clarity of objectives	0.50	3
				(b) Clarity of values and ethics	0.50	3
		Mechanism to achieve values and objectives	0.25	(a) Organizational structure adequacy	0.50	3
				(b) Status of planning	0.50	3
		HR Practices	0.25	(a) Status of performance orientation	0.50	2
				(b) Status of training and development	0.50	2
		Customer Relations Management practices	0.25	(a) Status of Patient Orientation	0.50	2
				(b) Status of patient grievance redressal systems	0.50	2

Table 2: Sub-system, KPAs and Measures under 'Q' (Weightage – 0.20)

System	weightage	KPAs	weightage	Measures	weightage	Evaluation 1 to 5
Functional Quality	0.40	Doctors	0.30	(a) Qualifications	0.50	4
				(b) Professional acumen	0.50	4
		Auxiliary staff	0.15	(a) Qualifications	0.50	4
				(b) Expertise	0.50	3
		Paramedical staff	0.20	(a) Qualifications	0.50	4
				(b) Skills	0.50	3
		Cure	0.25	(a) Right medication/surgery	0.50	4
				(b) Absence of side effects on account of treatment	0.50	3
		Care	0.10	(a) Absence of hospital acquired infections	0.50	3
				(b) Right procedures	0.50	3
Technical Quality	0.30	Pathological Services and Labs	0.30	(a) Status of technology	0.50	3
				(b) Rate of success	0.50	3
		Radio diagnostics	0.25	(a) Status of technology	0.50	3
				(b) Rate of success	0.50	3
		Ultrasound and X-ray	0.25	(a) Status of technology	0.50	3
				(b) Rate of success	0.50	3
		ECG technology	0.25	(a) Status of technology	0.50	3
				(b) Rate of success	0.50	3
Process Quality	30	Administration	0.20	(a) Access to staff	0.50	3
				(b) Easy procedures	0.50	2
		Ambience	0.20	(a) Housekeeping	0.50	2
				(b) Facilities	0.50	2
		Support Services	0.40	(a) Hospital stores	0.20	2
				(b) Engineering services	0.20	2
				(c) Dietary services	0.20	2
				(d) Bio-waste disposal	0.20	3
				(e) Laundry services	0.20	2
		Pharmacy	0.20	(a) Stocks	0.50	3
				(b) Service	0.50	3

Table 3: Sub-System, KPAs and Measures under 'R' (Weightage -0.20)

Sub-systems	weightage	KPAs	weightage	Measures	weightage	Evaluation
Promoter Satisfaction	0.50	Financial Returns	0.35	(a) Return on investment	0.50	1
				(b) Profits earned	0.50	1
		Growth	0.25	(a) Growth in assets	0.50	1
				(b) Growth in revenue	0.50	1
		Funds management	0.25	(a) Expense *control*	0.50	3
				(b) Income generation	0.50	1
		Societal Image	0.15	(a) Curing hospital	0.50	3
				(b) Caring hospital	0.50	2
Customer Satisfaction	0.25	Credibility	0.25	(a) Cure-Actual/Perceived	0.50	3
				(b) Care-Actual/Perceived	0.50	3
		Access	0.25	(a) To doctors	0.50	3
				(b) To facilities	0.50	2
		Responsiveness	0.25	(a) Guidance	0.50	2
				(b) Personal attention	0.50	2
		Empathy	0.25	(a) Dignity in dealings	0.50	2
				(b) Cordiality in dealings	0.50	2
Employee Satisfaction	0.15	Work place practices	0.30	(a) Fair dealings	0.50	2
				(b) Transparency	0.50	2
		Growth opportunities	0.30	(a) Training and development	0.50	2
				(b) Equal opportunities	0.50	3
		Compensation	0.40	(a) Equal to expectations	0.50	3
				(b) Performance orientation	0.50	2
Societal Satisfaction	0.10	Governance	0.25	(a) Transparency and ethics in decisions	0.50	3
				(b) Acceptance of the legal and statutory framework	0.50	4
		Values	0.25	(a) Integrity and honesty in practice	0.50	3
				(b) Accountability	0.50	2
		Social Cause	0.25	(a) Focus on societal needs	0.50	5
				(b) Creating value for society	0.50	4
		Eco-Management	0.25	(a) Pollution Control	0.50	3
				(b) Promotion of hygienic life styles	0.50	3

Five responses with graded values of 5, 4, 3, 2 and 1 have been proposed for each of the measures, with 5 and 1 representing the responses of the best and the worst grading respectively. Multiplying the response of the measure with the weightage factor should arrive at the graded response to each of the KPAs. The maximum value would be 5 and the minimum 1 on a scale of 1-5 for a KPA. To convert this score to an index on a 100-point scale, multiply the score by 20.

The index for a sub-system is determined by multiplying the response assessed of KPAs under a sub-system by the weightage assigned to the sub-system. The figure so determined requires to be multiplied with 20 to place the index on a scale of 1-100.

Index for the hospital as a system is obtained by multiplying the indexes of P, Q and R with corresponding weightage factors of P, Q and R, respectively, and adding up the score.

An Illustration: Tables 1, 2 and 3 illustrate the values of the various measures of a 30 bedded state run hospital. The weightage factors assumed for P, Q and R, for the various sub-systems, the KPAs and the measures are also noted in appropriate columns. The performance indexes (PI) arrived as per methodology explained are noted as under:

PI for P = 56.4%; PI for Q = 61.34%; PI for R = 42.30%

Performance Index for the hospital = 54.57%

Grading of Hospitals

Grades convey an instant message and are easy to comprehend. Besides, a difference of a few numbers either side of the score need not convey a fine demarcation of performance between two institutions. The small differences could also be attributed to subjectivity. It is, therefore, desirable to express the performance in grades. The index so arrived on 100 point score in each of the sub-systems P, Q and R, can be converted to a grade as under:

Index above 90	A
Index between 81-90	B
Index between 71-80	C
Index between 61-70	D
Index 60 or lower	E

Grade A represents excellent performance in all KPAs of the sub-system. There is a low risk of negligence on the part of the management and the patient can feel assured that he/she is in capable hands.

Grade B indicates a holistic performance in all the KPAs of the sub-system and a trend to move to the next grade. Patients should settle for the same in absence of a grade A hospital.

Grade C depicts a reasonable satisfactory performance and a potential to improve. The patient should look at the performance of the other sub-systems and decide if the other sub-systems enjoy better grades.

Grade D leaves much to be desired. If all the three sub-systems have D grades, the patient should consider the risks and visit the hospital only in emergency conditions.

Grade E is representative of lowest performance and the patient is advised to be cautious in dealing with the hospital.

The performance grades of a hospital would read like AAA or ABB or BAC or ECD or BCE etc. the first, second and the third digit standing for performance of P, Q and R respectively. AAA and EEE represent the extremes of the best and the lowest in overall performance. In the illustration cited the hospital will get a grading of EDE.

Administration of Grading

The proposed instrument of grading is applicable for all types of hospitals both in the private and the public sector. It is equally applicable to small hospitals as well as large speciality hospitals. The model incorporates sub-systems and KPAs both relevant to corporatized hospitals as well as health cure systems owned by welfare trusts. The differentiation is incorporated through weightage factors after taking into account the size, policies and the objectives of the hospital.

Apparently, there is a possibility of high subjectivity in assessment. This can be to a great extent eliminated through a group exercise and administering a structured questionnaire to a larger population to elicit response on KPAs, especially relevant to satisfaction values. There is also the necessity of transparency from the hospital administration and willing co-operation to provide information and record for analysis. This applies to willingness of the hospital to be a part of the process of performance grading.

As the instrument is to serve and provide guidance to society at large, the grading administration should be highly objective, consistent and unbiased. An independent authority created for this purpose should preferably carry this out. Medical Council of India or the Indian Medical Association or some similar authority could be asked to administer or regulate this function.

Grades can convey a meaningful message of performance if the comparison is sought between likes. For example, a hospital being run to achieve welfare objectives or to meet humanitarian causes devoid of any motives for financial gains cannot be compared with an institution that aims to maximize financial returns. Similarly, a primary health centre should not be compared with a speciality hospital. The two institutions vary in several perspectives. It is, therefore, necessary to categorize the hospitals and work out gradations for the hospital or institution as per the category under which it lies.

Public healthcare services

The state and the public bodies have set up a large network of health care centres all over the country. This is with a view to achieving the goals under the national health policy towards improving the health situation. The national policy takes into account the assessment of the current situation and an image of the future situation. Park (2002) differentiates health care systems as provided by the state under three levels:

(a) *Primary health care:* The purpose is to provide essential health care. A majority of the prevailing health complaints and problems are dealt with. The government renders this facility through primary health centres. The basic objective is to provide primary health care and educate the population about health problems. As per Park (2002), the functions of the primary health centre in India cover all the essential elements as outlined in the Alma-Ata Declaration. These include medical care, family planning, sanitation, prevention and control of locally endemic diseases, collection of vital statistics, education about health, training of health guides, health workers and basic laboratory services. Emphasis is on prevention of disease and to promote good health practices. As on 30th June 1999, a total of 22,807 primary health centres exist in the country.

(b) *Secondary health care:* At this level, more complex problems are dealt with. Cure gets more emphasis over care. The state provides the services through Community Health Centres and district hospitals rural hospitals, sub-divisional/tehsil/taluka hospitals. As per Park (2002) a total of 2,424 community health centres were established in the country.

These constitute the first referral points and provide full cure and care services. The smallest denomination is a 30 bed hospital and the same is required to be equipped with a number of essential medical services such as anesthesiology, medicine, general surgery, obstetric and gynecology, pediatrics, radio diagnosis. IS 12433 (Part 1) has detailed functional programmes. The size of the community hospitals varies and is usually referred to in terms of provision of beds.

The specialist at the community health centre may refer a patient directly to the state level hospital.

Besides, there is a large net work of hospitals, similar to community health centres to provide services to industrial workers under the ESI scheme. Other state agencies that provide similar health care to their employees include Defense Medical Services, the Indian Railways and the Central Government Health Scheme.

(c) Tertiary Health Care: These encompass super-specialist cure and care institutions with provisions of research facilities. Very often, medical education at the graduate/post graduate level is included. These are regional institutions and constitute the last referral points amongst public health systems. Some of these have an all India character and represent the highest standards of cure. These represent the art of science and medical technology. The private sector has not yet made a significant entry in this sector. For many medical complications, these institutes are the only alternatives in the country for both rich and the poor patients. Tertiary health care as well as medical research, therefore, continues to be largely in state hands. As profit is not the objective, these require extensive funds from the state for expenses. The society considers their existence as a matter of pride.

Health care systems in the Private Sector

Financial returns are either the main objectives or one of the principal explicit or implicit aims. Private practice of medicine provides health services to a large number of people, especially to those who also seek the care component at a cost. Many institutions are being promoted and incorporated to be run as professional limited companies. Other investors take recourse to setting up of cure and care facilities with provision of a panel of specialists who, under various types of arrangements, share the earnings with investors. The various available arrangements can be sub-classified as under:

(a) General Practitioners, Consultants and Owner Clinics: These can be described as centres without provisions of in-patients or hospitalization. These provide mainly curative services. These are run, owned and operated by medical practitioners in their individual capacity/partnership. The infrastructure installed and facilities made available depend on the type of medical services offered. Imaging centres, pathological labs, ultra-sound centres fall in this category. Park (2002) estimates that the general practitioners constitute 70% of the medical profession. Most of these tend to congregate in the urban areas. The services are available to anyone who can afford to pay. The sector is essentially unorganized from the point of provision of minimum diagnostic facilities, or infrastructure or emergency aid. Many of the consulting chambers lack basic amenities for examination of patients.

(b) Private Hospitals, Polyclinics, Nursing Homes, and Dispensaries, General hospitals: These are established as alternates to the state run hospitals for more affluent and discerning customers who look for better attention from the management. The functional programmes are on the lines of Community Health Centres. Some of these are established with aid from the state in the form of land at highly subsidized rates or other concessions. In return these hospitals provide free OPD or a percentage of beds to the poor at lower rates. These can be again sub-classified as per the capacity, that is the number of beds.

Speciality Hospitals: Many hospitals are promoted to cater to specific category of ailments as heart, spinal injuries, neurology, etc. This is a new phenomenon. The

out the task of evaluation. As the exercise is meaningful only if likes are compared with likes, it is recommended to categorize the health system. A classification has been proposed for different ownership styles. Three ownership styles have been considered – the state owned, the private and the trust owned. Under each of these categories, nine classes of hospitals have been proposed. These are based on the size of the institutions.

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There is no security on this earth; there is only opportunity.

– Douglas MacArthur

Feature

Capital Account Liberalization & Management of Capital Funds

U. Arabi

In this paper, an attempt is made to examine the process of Capital Account Liberalization and Management of Capital Inflows. The inflow of capital funds into the economy help to generate economic growth along with measures to minimize BOPs crises. However the aim is to stabilize the flow of capital funds which require an appropriate policy package by the monitory authority in the country. The emerging policy issues are highlighted in the paper showing how effectively cross border capital flows can be managed with a specific thrust upon adoption of different capital flows controls.

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The process of liberalization and globalization initiated in the early 1990s aimed at enhancing productivity and efficiency at all levels by integrating the Indian economy with global economies. A significant step in this direction has been the movement of cross border capitals, which in turn encourage growth and even eases the balance of payments crisis in developing countries. In the Indian context, it would perhaps be more appropriate to invite such private capital since the domestic savings are a constraint in the process of domestic capital mobilization, though it would have been desirable to generate capital through different measures like increasing the domestic savings rate by suppressing consumption, high taxation or even by appropriating profit through ownership of commercial enterprises as is evident in India in the 1950s.

Although in the early decades of planned development allocation decisions were made by the Government or its agencies, the state dominated development paradigm had sifted sharply in India in recent years, with more emphasis on the private sector. The two major elements of Indian policy frameworks that had resulted in an adverse effect in the efficiency of the private sector were (a) extensive bureaucratic control over production, investment and trade and (b) inward looking trade and foreign investment policies.

In this direction, however, the New Economic Reforms measures (1991) were designed and adopted to achieve many targeted ambitious aims besides filling the resource gap of balance of payments and technology transfers between countries. This is more evident in the words of the present RBI Governor; "Greater Internal Capital mobility and integration of global financial market contributes much to the domestic growth of different sectors, domestic savings continued to be important for development. In recent years, the increased mobility of capital has ensured that global resources would follow to countries which can show high growth and high returns, it is possible now for India to take

Table 1: Country Wise Break up of FDI Inflows (During August 1991 to October 2002)

(US $ million)

Rank	Country	Sep 1991 - Dec 1995	%	Jan 1996 - Dec 2000	%	2001 Jan-Dec	%	2002 (Jan-Oct)	%	Amount of FDI inflow (Rs. Crores)	% of the Total
1.	Mauritius	551.7	24.96	3596.2	38.45	1625.1	62.68	1038.1	57.2	6811.1	38.2
2.	USA	537.5	24.32	2108.3	22.54	322.9	12.45	225.9	12.45	3194.6	17.1
3.	Japan	216.4	9.79	759.7	8.12	211.2	8.14	67.5	3.72	1254.8	6.8
4.	UK	361.5	16.35	355.2	3.79	60.0	231	211.0	11.64	988.0	5.2
5.	Germany	159.2	7.2	579.4	6.19	107.1	4.13	91.2	5.02	936.9	5.0
6.	Netherlands	145.7	6.59	537.6	5.74	77.6	2.99	84.3	4.64	845.0	4.5
7.	Korea	32.7	1.47	556.8	5.95	4.5	0.17	13.9	0.76	667.9	3.1
8.	France	108.9	4.92	232.2	2.48	125.0	4.82	35.0	1.92	501.0	2.8
9.	Italy	16.9	0.76	357.3	3.82	28.2	1.08	43.2	2.38	441.7	2.4
10.	Singapore	94.6	4.28	268.7	2.84	35.2	1.35	3.7	0.20	406.1	2.3

Source: Economic Survey, 2002-03 pp. 133.

advantages of a virtuous circle of higher growth; higher external capital in flows and higher domestic incomes and savings, which in turn can lead to further growth." (Bimal Jalan 2002).

Thus, the impact of Indian economic reforms on economic performance has been the subject of academic study and public debates in India. Indeed, the cross-border capital inflows to India in recent years influenced the growth of the economy in a variety of ways. But sustaining the growth process was also essentially required which depended on several policy decisions of the monetary authorities and the Government public policies which are in the form of fiscal packages.

Against this background, a sincere effort is made in this study to examine different aspects relating to the major policy issues on the capital account convertibility (liberalization) process practiced in India after the Asian crisis and the efforts needed and policy framework to administer the capital inflows into India in recent years.

Trends, nature and composition of Capital Inflows

In the regime of privatization, liberalization of the regulations for foreign direct investment is required not only to integrate India with the global economy but also to enhance the levels of available resources. Further, productivity enhancement in different sectors in the domestic economy is associated with an increase in private investments, resulting in greater domestic competition and export promotion.

The evolution of cross-border capital flows to different countries in the 1990s could be noticed. For instance, in 1990, there were 40 countries for which the rate of FDI to gross capital formulation was 5 per cent or more. For India, in that year this ratio was only .02 per cent. By 2000 the number of countries where the ratio of FDI to gross capital formation was 5 per cent or more had more than doubled to 9.9, while in India, this ratio was only 2.1 per cent.

A country-wise breakup of FDI inflows between 1991 to 2002 (Oct) is presented in Table 1. This shows that the most important countries are Mantises (38.7%), followed by the U.S. (17.1%) and Japan (6.8 %). The special role of Mauritius here is likely to be the consequence of the special tax treatment accorded in India to investments routed through Mauritius (Table 1).

Policies in the post reforms period has emphasized greater encouragement and mobilization of non-debt creating private capital inflows for reducing reliance in debt flows as the chief source of external resources. Progressively liberal policies adopted in this regard have led to increasing inflows of foreign investment in the country, both inters of FDI as well as portfolio investment. FDI inflows are an indicator of the foreign investor community's long term stake in the host economy.

A time series profile of FDI inflows into selected Asian host economies is given in Appendix Table 2. In 2001, developing economies of Asian accounted for around 14 per cent of total global FDI inflows. China has been the largest recipient of FDI inflows among the developing economies of Asia with its share in total FDI of these economics increasing from 43 per cent in 1996

Table 2: FDI inflows in select Asian Economies (US $ Million)

	1996	(%)	1997	(%)	1998	(%)	1999	(%)	2000	(%)	2001	(%)
World Developed	386140	NA	478082	23.81	694457	45.25	1088236	56.70	1491934	37.09	735146	-50.72
Economies Developing	199108	NA	267947	21.84	484239	80.72	837761	73.00	1227476	46.51	503144	-59.00
Economies	152685	NA	191022	25.10	187611	-17.85	225140	20.00	237894	5.66	204801	-13.91
Asian	93331	NA	105828	13.38	96109	-9.18	102779	69.40	33707	30.09	10266	-28.03
South East												
Asia	87843	NA	96338	9.67	96252	-10.46	99990	15.92	131123	31.13	94365	-28.03
China	40180	NA	44237	10.09	43751	-10.98	40319	-78.44	40772	11.23	46846	14.89
India	2526	NA	3619	37.86	2633	-27.29	2168	-17.66	2319	70.63	3403	46.74
Indonesia	6194	NA	4677	-24.49	-356	-107.61	-2745	-87.10	-4550	-26.57	-3277	-27.97
Korea	2325	NA	2844	22.32	5412	-90.29	9333	72.45	9283	-0.5	3198	-85.30
Malaysia	7296	NA	6324	-17.43	2714	-57.08	3895	43.57	3788	-2.74	554	-85.30
Philipians	1520	NA	1249	-17.82	1752	40.27	578	-67.00	1241	114.70	1792	44.39
Singapore	8608	NA	10746	24.83	6389	-40.54	11803	84.73	5407	-54.18	8609	59.21
Thailand	2271	NA	3626	59.66	5143	41.83	2561	-30.76	2813	-211.31	3759	33.62

Source: Economic Survey, 2002-03, pp. 120.

to almost 46 per cent in 2001. India, though behind China in attracting FDI inflows, has marginally improved its share in total FDI inflows from 2.7 per cent in 1996 to 3.3 per cent in 2001. A sharp rise in the volume of FDI inflows in the Indian economy in 2001-2002 thus improved (Table 2) its growing attractiveness as an investment destination.

In the aftermath of the East Asia Crisis in 1997-98, overall net private capital flows to emerging markets, including those in developing Asia, experienced sharp decline. Though the decline is largely attributed to reduced volumes of portfolio inflows, FDI inflows also fell. The reduction in FDI inflows in the Indian economy after 1997-98. (Table 2), therefore, is reflective of the overall depressed trends of private capital flows in the emerging market, including developing Asia (with the notable exception of China).

In the aftermath of the East Asia Crisis in 1997-98, overall net private capital flows to emerging markets, including those in developing Asia, experienced sharp decline.

Against this subdued backdrop, the spurt in FDI inflows in India in 2001-2002 is remarkable for several reasons. Firstly, in terms of overall trends in FDI inflows into the emerging markets of developing Asia, the year 2001 was hardly encouraging. Even then, the Indian economy revealed the highest FDI inflows in the post reforms period, surpassing the previous high of 1997-98. Secondly, the major part of the year 2001-2002 was characterized by a synchronized slowdown in the global economy, which dampened investor sentiments and tightened international capital markets. But India received higher FDI inflows notwithstanding the regicide in global financial markets. Finally, the year 2001 saw the Indian economy groping with exogenous shocks like the Gujarat earthquakes (Jan. 2001) and the terrorist attack on the Indian Parliament, Dec. 2001, apart from the calamitous development on Sept. 11, 2001.

In line with more liberal policies pertaining to overseas investment by Indian firms, overseas direct investment (ODI) outflow from India has been exhibiting rising trends in recent years. Aggregate outflows rose from US $ 0.2 million in 1995-96 to roughly US $ 1.2 billion in 2000-01. In 2001-02, the actual outflows declined to around US $ 0.9 billion. However the previous year witnessed a sharp rise in the volume of approved investment, which shot up from US $ 1.4 million in 2001-01 to US $ .3 billion in 2001-02. The increase in approvals was largely on account of higher approvals sought for foreign equity investment, which also explains the lower materialization of actual outflows, compared to approvals, since the global equity markets suffered from sharp erosion in confidence, particularly after Sept. 11, 2001. Foreign exchange inflows from Indian investments

Table 3: Composition of Capital Flows to India

	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02
A Direct Investment	97	129	315	586	1314	2144	2821	3557	2462	2155	2339	3904
a. Govt.	66	222	280	701	1249	1922	2754	1821	1410	1456	2221	
b. RBI	–	–	89	42	171	169	135	202	179	171	454	767
c. NRI	–	63	51	217	442	715	639	241	62	84	67	35
d. Acq of share	–	–	–	–	–	11	125	360	400	490	362	881
B Portfolio inv	6	4	244	3567	3824	2748	3312	1828	–61	3026	2760	2021
a. GDRS	–	–	240	1520	2082	683	1366	645	270	768	831	477
b. FIIS	–	–	1	1665	1503	2009	1926	979	390	2135	1847	1505
c. Offshare Funds & other	6	4	3	382	239	56	20	204	59	123	82	39
Total (a+b)	103	133	559	4153	5138	4892	6133	5385	2401	5181	5099	5925

Source: Economic Survey, 2002-03, pp. 119

in joint ventures and wholly owned subsidiaries have been steadily rising while inflows rose from US $ 0.4 million in 1999-2000 to US $ 0.05 billion in 2000-01. There was a more than five fold increase in 2001-2002, when the inflows aggregated around US $ 0.3 billion. In the first half of 2003, inflows from overseas investments were around US $ 0.03 billion.

In Table 3 the composition of capital flows into India (the aggregated portfolio inflows) is given. The private portfolio investments inflows in the emerging market dropped sharply after the East Asian crisis. Developing Asia has not been an exception in this regard, with the year 2001 experiencing a net outflow of US$ 13.5 billion from the emerging market in the region. The Indian economy, though not experiencing net outflows, had the third lowest volume of portfolio investment in 2001-2002 for the period 1993-94 to 2001-2002.

Among the various components of portfolio investments, foreign institutional investments comprises the bulk of portfolio inflows (Table 3). Country and region specific factors have important roles to play in determining the investment decision of portfolio investments. In the year 2002 perspectives for expected returns from various emerging market became sub deed.

High volumes of non-resident deposits in the Indian economy are in sharp contrast to low FDI inflows attributable to expatriate origin (Table 3). In this regard, it is mentionable that the various NRI schemes for FDI that were in vogue during the Foreign Exchange Regulation Act (FERA 1973) regime, have since been subsumed under the Foreign Exchange Management Act (fema 1999). At present, there are no separate schemes for FDI.

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FDI and infrastructure financing in India

The nature and composition of FDI is highly significant in determining the impact on overall growth in a country like India. For instance, the more stable the capital flows, the long term consideration for economic growth can be regarded or recognized. However, utilization of these funds for financing long term capital investment in the infrastructure continues to be a rare phenomenon in the Indian context. Advancements in technology and the extent to which the BOPs deficits could be rectified by the economies is a matter of great concern which also focuses on infrastructure developments. In this regard, the problem of utilizing the private foreign capital funds for infrastructure is further compounded by certain inherent characteristics of infrastructure in general, like the features of non-excludability. externality, natural monopoly, inelastic demand and involvement of huge capital investments with long gestation period making the

Advancements in technology and the extent to which the BOPs deficits could be rectified by the economies is a matter of great concern.

Table 4: Sectorwise Inflow of Capital Amount Rs. crores (US $ Millions) (During Aug 1991 to Oct 2002)

	Rank Sector	Amount of FDI approves	% of the total FDI Approves	Amount of FDI inflows	% of total FDI inflows	Inflows as % approvates
1.	Energy					
	(i) Power	43,481	15.4	–	–	–
		(11,855)				
	(ii) Oil refinery	33,964				
		(9,060)	12.0	–	–	–
	Total (I+II)	77,445		7,475		
		(20,915)	27.4	(1813)	10.4	9.7
2.	To communicate (Radio paying cellular mobile basic telephone services)	56,273		9,300		
		(15,197)	19.9	(2.259)	12.9	16.5
3.	Electrical Equipment (Computer software Electronics)	27,853		10,058		
		(7,027)	9.8	(2,488)	13.9	34.1
4.	Transportation Industry	20,981		7.800		
		(5,512)	7.4	(1,984)	10.8	37.2
5.	Service Sector (Financial and non financial)	18,416		5,968		
		(4,932)		5,968		
			6.5	(1,573)	8.3	32.4
6.	Metallurgical Induction	15,852		991		
		(4,253)	5.5	(252)	1.4	6.4
7.	Chemicals (other than fertilizers)	12,852		4,840		
		(3,677)	4.5	(1,316)	6.7	37.7
8.	Food Processing Industries	9,379		2,884		
		(2,715)	3.3	(788)	4.0	30.8
9.	Hotels & Tourism	4,902	546			
		(1,385)	1.7	(138)	0.8	11.1
10.	Textiles	3,466		1,059		
		(1,006)	1.2	(290)	1.5	30.6

Source: Economic Survey 2003, pp. 135.

financing of infrastructure more difficult in the Indian context. More interesting is the question of how such funds can be used as a feasible solution for the different needed infrastructure facilities in different parts of the economy in a given time frame. Though it is easier to attract foreign capital for power, telecom as well as transport, the cost recovery is also much easier as the costs may be equated to the user charges for facilities being utilized.

A sector wise inflow of capital which is presented in Table 4 shows that the most important sectors are telecom, electrical equipments including software, energy and the transportation industries. The four sectors accounted for roughly 50 per cent of FDI inflows. Electrical equipment including computer software and electronics are the sectors which have attracted the highest approval for technology transfer (Table 5).

Table 5: Sectorwise approval of technology transfers (Aug 1999 to Oct 2002)

	Sector	No. of Technical Collaberation (TC) approved	Percentages with total approved
1.	Electrical equipment (including Computer Software and Electronics)	1174	16.4
2.	Industrial Machinery	832	11.6
3.	Chemical (other than fertilizers)	813	8.4
4.	Transportation Industry	604	4.9
5.	Metallurgical Industry	355	4.9

Source: Economic Survey, 2002-2003, pp. 135

Clear evidence on total foreign technology agreement (FTA) and foreign direct investments (FDI) approval is available in Table 6. During 2002, FDI

proposals approved declined to Rs. 11,140 crores from the level of Rs. 26,875 crores seen in the corresponding period of the last year. (Table 6). This is mainly due to the fact that most activities are now an the automatic route, wherein actual out flows are also treated as the approved amount. Actual FDI inflows during 2002 showed an increase to Rs. 21,285 crores as compared with Rs. 19,265 crores in the corresponding period of the last year. There has been a sharp decline in the number of Foreign Technology Agreement (FTAs) since the peak level of 982 achieved in 1995.

Table 6: Total foreign technology agreement (FTAS) and foreign direct investment (FDI) approvals

(Rs. in Crores)

Year (Jan to Dec)	No. of approvals	No. of FDS approvals	Amount approved of FDI	Actual inflow of FDI
1991	661	289	534	351
1992	828	692	3888	675
1993	691	785	8859	1787
1994	792	1,062	14,187	3289
1995	982	1355	32,072	6820
1996	744	1559	36,147	10389
1997	660	1665	54,891	16,425
1998	595	1191	30,814	13,344
1999	498	1726	37,039	19,342
2001	288	1982	26,875	19,265
2002	307	1966	11,140	21,286
Total	7,464	15,998	2,84,812	1,29,838

Source: Economic Survey, 2002-2003, pp. 135

The East Asian Financial Crisis & FDI Controls

The South East Asian collapse was the logical culmination of an in appropriate financial liberalization strategy with volatile capital flows. In other words, the capital account liberalization and controls has become an extensive debatable issue after the East Asian Crisis. The main focus of the debate related to the desirability, form and content of capital controls, risk containment strategies in external debt management and desirable sequence of capital account convertibility (liberalization). Further, the accumulation of short term liabilities of banks and corporates and poor quality of risk assessment is regarded as a major source of vulnerability in the Asian Crisis.

The capital account convertibility (liberalization) may be in general terms understood as a gradual and continuous method of attracting foreign capital flows to finance domestic investment activities given the imperfection in the domestic capital market to finance the same.

In almost all countries, since the outbreak of the South East Asian crisis, the policy makers are pre-occcupied with examining the feasible measures to ease the aftermath influence of the Asian Crisis on different sectors. This become more relevant in India, as the attitude to foreign investments in India in the recent past differed sharply as India has been extremely cautious about FDI but relatively open to foreign portfolio investment (FPI).

Recent increases in the mobility of international capital reveal that private capital flows now dominate with reduced official capital flows. This indicates that an increase in portfolio capital flows towards volatile investments in the short period expose individual countries to enhanced volatility and sudden withdrawl risks. However, efforts to pursue higher return and portfolio diversification, which depends on market oriented reforms necessarily augment the liberalized assets of financial markets. Meanwhile, the rising incidence of financial crisis definitely rises the concern about how to link issues together, because the increased cost of financial fragility should not exceed the gains of financial regulation in many developing countries. Further, the dismantling of capital controls to integrate financial markets with the global network may be attempted with more caution.

Recent increases in the mobility of international capital reveal that private capital flows now dominate with reduced official capital flows.

Capital flows affect a wider range of economic variables in the domestic economy. For instance, effect on exchange rates, interest rates, foreign exchange reserves, savings investment, besides a host of domestic monetary conditions are significant for India as the process of capital account liberalization was already operational. However, these effects are more common in recent years. As is apparent in theory, an inflow of foreign capital tends to raise the level of domestic expenditure in the economy resulting in changing the demand potential for non-tradable goods causing the real exchange rate appreciation to have a bearing upon India as well. In recent years, the IMF has viewed capital account convertibility with free trade in goods and services to be scheduled logically by the free movement of financial and physical assets.

The liberalization of FDI was accompanied by deregulation of interest rates and towards a market determined exchange rate. Hence, important domestic financial sector reforms must follow in the heels of such a development. Capital market reforms call for the empowering of regulatory authorities, mainly to punish market violations and strengthen overall discipline.

A key component of financial sector reform is that of capital markets, where investors' confidence needs to be built up through a credible supervisory authority and a general strengthening of shareholders' rights. The portfolio and capital account liberalization are father cautious recognizing that capital inflows can often be speculative and destabilizing. Thus, financial liberalization without adequate safeguards is generally viewed as one of the factors responsible for the crisis.

Factors in Management of Capital Funds Controls

An impact assessment of capital inflows depends on the nature of capital flows to the domestic economy. Since the FDI flows are permanent in character, they have an immediate favourable impact on the real sector of the economy, like investment, employment, output etc. Though all direct foreign investment flows do not stimulate domestic capital formation in the short run, the larger flows raise the issue of its sustainability on growth process. Further, cross-border capital movements usually depend on favourable internal and external, both push and pull factors. The internal factors which facilitate the foreign capital inflows include the higher price stability, existing structural reform programme and even the subsequent acceleration process needed to boost further economic growth when an economy adopts a tight monetary policy to keep the interest rate seemingly high, thus favouring a more stable exchange rate regime, which will subsequently determine capital inflows.

The experience in developing countries reveal that the long term efficiency of free capital movement is rather significant and care for such capital controls either as a temporary measure or on a permanent basis seems relevant, which is based on the assumption that, in developing countries, the financial markets are characterized by volatility and irrational expectation. Further, it is also felt that without prior action for strengthening their financial system, the emerging markets cannot follow up capital account liberalization. In this context, possible amendment of IMF's Articles to extend its jurisdiction over the capital account though thought of, but the IMF itself has acknowledged that there is no unique path that defines orderly capital account liberalization. However, a significant amount of liberalization of capital account convertibility has already taken place in the developing countries under the existing Articles. Though the external capital acts as a complement to domestic savings in a country like India, the short term reversible flows can also have a negative effect on the economy, particularly during periods of political or economic uncertainty. On the contrary, large flows impose extensive damage to the financial sector and also result in disproportionate output loss. Therefore, it must be remembered that merely by lifting all capital controls, the markets of a developing country do no get as deeply integrated as a developed country's market. Hence, as such, each country would need to decide on its own path of capital account liberalization. The timing and sequences are likely to depend upon the extent of stability and institutional structure of the domestic financial sector. As it is evident now, Indian policy on the capital account has been predominantly influenced by the recommendations of the Rangarajan Committee.

Merely by lifting all capital controls, the markets of a developing country do no get as deeply integrated as a developed country's market.

A major factor relevant and to be considered most appropriate is the state of the exchange rate regime. Commonly used exchange rates which are neither a currency brand nor a free float, lack a state of stable features, under which an intermediate regime, consisting of different types may be followed like fixed pegs, crawling pegs, fixed rates within brands-managed floats with no pronounced path, and independent floats with foreign exchange intervention moderating the rate of exchange and preventing undue fluctuations. There is a degree of agreement that stability in the exchange rate is well served by the stability in the conduct of monetary policy. Essentially the capital account convertibility, monetary independence and exchange rate stability reflects the actual experience of the behaviour of the exchange market in a country.

The importance of reserves in the era of capital mobility is shown by Stanley Fisher (2001) as,

> Reserve matter because they are a key determinant of a country's ability to avoid economic and financial crisis. This is true of all countries but especially emerging markets open to volatile international capital flows. The availability of capital flows to offset current account shocks should on the face of it, reduce the amount of reserves, a country need. But access to private capital is often uncertain, and inflows are subject to rapid reversals, as we have seen all too often in recent years. We have also seen in the recent crisis that countries that had big reserves by and large did better in withstanding contagion than those with smaller reserve.

This issue of real exchange rate and removal of capital account restriction requires further insight and in depth analysis. This is because, the conflicting policy choices are bound to arise in an economy where the capital inflows are associated with real appreciation. The domestic monetary policy is targeted to achieve monetary stability and management. However, interaction by monetary authorities to stabilize the exchange rate and accumulation of foreign currency purchase will have further implication for monetary management in the domestic economy. Then monetary policy has to be made more effective to overcome exchange rate instability effects upon the domestic economy objectives.

Advocating a case for a more flexible exchange rate policy carries with it the risk of appreciation as well. A significant implication of real appreciation is on the export potential of the economy which may even result in loss in external trade competitiveness. This in turn disrupts the process of trade liberalization and even result in development processors within the economy as a result of temporary inflows of capital, where the required real adjustment costs associated with exchange rate changes may be even more.

The kind of comprehensive approach required for reserve management in India is well recognized by the RBI Governor, Bimal Jalan (Monetory Credit Policy April 29, 2002), thus,

> A sufficiently high level of resources is necessary to ensure that even if there is prolonged uncertainty, reserves can cover the liquidity at risk on all accounts over a fairly long period. Taking this consideration into account India's foreign exchange reserves are now very comfortable. The prevalent national security environment further underscores the need for strong resources. We must continue to ensure that, leaving aside short-term variation in reserve level, the quantum of reserves in the long run is in line with the growth of the economy. The size of the risk adjusts capital flows and national security requirements. This will provide us with greater security against unfavourable or unanticipated developments, which can occur quite suddenly.

The Emerging Issues

In the aftermath of the currency crisis, the capital controls emerged as a self-protection device to safeguard the pressures of heavy capital surges, which can be an effective solution in the short term to manage the external capital flows.

Currently the capital controls can be used effectively, similar to other policy instruments like greater exchange rate flexibility, part sterilization and encouraging out flows to manage the capital account subject to the condition of minimizing the costs associated with a single policy option, rather than many. Further in terms of current convertibility, India has adopted Article VIII of the IMF, which implies that a member country embracing Article VIII undertakes to refrain from restriction on current payment and discriminatory currency practices.

Infact, steady foreign investment inflows have been instrumental in strengthening the balance of payments in the recent past. Given the potential for high direct foreign investments in India a further consideration of liberalization of the investment region in this area is likely to result in enhanced foreign investment inflows, thus supporting the investment deeds of the economy for higher growth and providing strength to prudent debt management.

The important suggestion to control capital flows thus include the accumulation of short term liabilities of the banks and corporates evidenced as one of the major source of vulnerability in the Asian crisis. In order to restrain such short-term capital flows, which are volatile in character, important suggestions thus include the need for effective monitoring, imposing of Tobin Tax (a tax on spot transaction and unremunerative resource requirement), as prevalent in Chile.

Surging foreign exchange reserves have provided an opportunity towards further relaxation of existing capital controls. Such a measured approach leading towards capital account convertibility needs to be continued. The rising reserves also provide a greater flexibility to exchange rate management towards developing deeper markets for foreign exchange transaction. The reserves further provide an opportunity to expedite completion of the trade liberalization agenda.

Surging foreign exchange reserves have provided an opportunity towards further relaxation of existing capital controls.

Undoubtedly, capital flows ease external constraints and help to achieve higher investment and growth, since they are vehicles for the transfer of technology and management skills. But a sustained growth of the economy requires effective management of capital funds as capital controls become a part of capital inflow management with the domestic economy. In this regard, it is worth noticing that Prof Kurgman and Baghavathi are in favour of temporarily or permanently giving up capital account convertibility. Kurgman advocates capital controls parley as a stop gap measure on grounds that it allows crisis hit countries to adopt more expan-

sionary monetary and fiscal policies, hence promoting a faster recovery of the real corporate sector and non-performing loans in the banking systems. He further argues that, the controls must not be a substitute for reforms, rather they must complement reforms. In his view, controls must in any circumstance be imposed to defend an over valued exchange rate. At best, they should be very temporary measures imposed to stabilize the economy in the short run (C. Rangarajan 2000).

Though FDI flows along with improved technology brings with it improved managerial skills and opens up new marketing channels for developing countries, it must be kept in mind that the inflow of capital should be supported by higher capital productivity and export intensity (Veena Pailwar 2002). In this context, adoption of a national competition policy will help India take part in the possible international negotiation of trade and competition policy in the framework of W.T.O.

Conclusion

However, much can be gained with the following propositions:

(a) The need for effective anti-trust regulations in developing countries.

(b) The FDI policy needs to be more strategic sector perspective so that local capacity can be further exploited.

(c) Though the Trip's Agreement obligation do not affect the host country, it will have an adverse effect on R&D activity capacity in the chemicals and pharmaceutical industry in a country like India.

(d) Fear of use of foreign brand names i.e. the competition policies provide an access to their parent brands and trade names (non-price modes of rivalry characterized by heavy reliance on marketing and advertising) to differentiate their products.

(e) The need for an international discipline on investment incentives (investment and tax incentives).

(f) The need to further participate in the WTO negotiations of TRIM's since the new international trading regime under the aegis of the WTO covers issues which have an important bearing on the ability of national governments in regulating the pattern of FDI inflows.

The foregoing analysis tries to highlight the following policy concerns relating to FDI management and sustaining economy:

Firstly, the inflow of capital (FDI) as a continuous flow process has to be effectively managed, since any fluctuations in the capital supply results in unwanted monetary or fiscal pressures in the economy. Sustained or balanced growth is possible by achieving monetary and fiscal stability.

Secondly, since FDI can be flown into many sectors of economic significance, the prioritization of sectors has to be the guiding philosophy, instead of pouring capital to the sectors which are largely inflationary in character.

Thirdly, in meeting the capital deficiency of the economy through greater amount of trade liberalization packages, the existing economic or social sectors have to be carefully protected through proper policy regulations in order to make them more competitive.

In summary, the need to further encourage free flow of foreign capital, a policy measure has to be evolved with the prime concern of how best the Govt. in India can go above the clutches of public debt. Thus, the need has come to evolve a strategy in the wake of the changing trade and investment regime under WTO, to see how best the domestic capital resource base can be identified and strengthened, on the one hand, and what would be the future response of the government of India towards the changing capital flow climate in the near future in the wake of preparations with WTO on TRIM related issues.

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No institution which does not continually test its ideals, techniques, and measure of accomplishment can claim real vitality.

– John Milton

Feature

Manufacturing SSIs Under WTO Regime in Karnataka

M.R. Narayana

This paper provides an empirical framework for the design and conduct of a sample survey for capturing the performance of manufacturing SSIs under the WTO regime. Further, the paper demonstrates the applicability of the framework by implementing the design for sample manufacturing SSIs in Bangalore Urban district in Karanataka State. The results and implications of the study are highlighted for consideration of policy makers, SSI managers and researchers with special reference to accomplishing the targets of Mid Term Export Strategy 2002-07.

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India joined the WTO as a founder-member on January 1, 1995. In essence, the WTO is an institutional framework for member countries (or their national governments) to promote free trade (by removal of tariff and non-tariff barriers) in goods and services and free mobility of trade-related factors of production. All agreements of the WTO are the outcome of negotiations between member countries and are enforceable through the dispute settlement mechanism.

The most important WTO agreements, which are relevant for manufacturing SSIs, are the Multilateral agreements on trade in goods including General Agreement on Tariff and Trade (GATT) 1994 and its 12 associate agreements. Multilateral agreement on IPRs is called Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS).

Of the 12 associate agreements under the GATT, the most important agreements for manufacturing SSIs are as follows. (i) Agreement on Implementation of Article VII of GATT 1994 (Customs Valuation); (ii) Agreement or Preshipment Inspection; (iii) Agreement on Technical Barriers to Trade (TBT); (iv) Agreement on Application of Sanitary and Phytosanitary Measures (SPM); (v) Agreement on Import Licensing Procedures; (vi) Agreement on Safeguards; (vii) Agreement on Subsidies and Countervailing Measures (SCM); (viii) Agreement on Implementation of Article VI of GATT 1994 (anti-dumping); (ix) Agreement on Rules of Origin.

The Planning Commission's (2001) report is the latest and most comprehensive official document on the national-level development of small-scale enterprises in the country. Chapter 4 to this report describes the broad implications of WTO on the small-scale sector in terms of GATT, ATC, SCM, and Agreement on Dumping Practices, TRIPS, and Agreement on Government Procurement, TBT and SPM. Further, the report outlines the efforts that should be made by India to protect her legitimate interests. These efforts include adequate

preparedness for WTO meetings, increasing awareness about WTO, strengthening anti-dumping measures, development of legal expertise, opening up of Indian markets keeping domestic economics agents in view (e.g. impact of opening up of the economy on output and employment) and improving quality of workforce.

The Small Industries Development Bank of India, (SIDBI), (2001) has reported the impact of policy initiatives in the form of surveys, results and proceedings of seminars on SSIs in the post WTO period. A summary of these studies is presented in Table 1.

In particular, the surveys and seminars reveal the following. First, coverage of states, sectors and sample units vary between surveys. Nevertheless, major findings with regard to factors, which influence competitiveness in production or exports, are specific to sectors rather than for states. Thus, sector-specific, interventions are sought in these studies. Second, impact of globalisation and WTO are separate. For instance, the first and fourth studies focus on the impact of globalisation and reforms rather than on the impact of WTO on SSIs.

This paper is an attempt to assess the performance of manufacturing SSIs under the WTO regime in a state-specific context. The main objectives are to (a) provide an empirical framework from the design and conduct of a sample survey for capturing the impact of WTO agreements on SSIs; (b) demonstrate the applicability of the framework by implementing the design for sample SSIs in Bangalore Urban district in Karnataka State; and (c) highlight the survey results and lessons for consideration of policy makers and professional researchers on SSIs with special reference to accomplishing the targets of Mid Term Export strategy 2002-07 of the Government of India, as they are related to SSI in the country.

Design and conduct of the study

The Government of India has come out with the Mid Term Export Strategy 2002-07. Table 2 highlights the role of major SSIs products/commodities in the projected export growth of India in the Mid Term Export Strategy, viz., leather and manufactures, sports goods, chemical and allied products, engineering goods, electronics goods, and textiles. The share of these six commodities is about 54 per cent in the actual (or projected) exports, chemicals and allied products (about 12 per cent), and engineering goods (about 13 per cent). Thus, the SSI sector has a major role in accomplishing the export targets of the Mid Term Export Strategy.

The SSI sector has a major role in accomplishing the export targets of the Mid Term Export Strategy.

Further, the strategy has identified a list of 35 extreme focus items (comprising agricultural and non-agricultural items) under 21 product groups. Of the 29 non-agricultural items, 21 items are included in this study, as relevant for SSIs. These selected items are as follows: Auto components; Drugs, Phamcutes and Fine Chemicals; Dyes/intermediates & coal tar chemicals; Electric Power Generation & Distribution Systems; Footwear; Hand Tools; IC engines and parts; Industrial Castings and Forging; Tomato paste products; Tropical fruit juice; Pulp and concentrates; Preserve mushrooms; RMG cotton, including accessories; RMG silk; RMG Manmade fibres; RMG wool; RMG of other textile materials; Computer software; Manmade yarn, fabrics and madeups; Handicrafts (toys and agarbathis) and Electronics and precision engineering.

For collection of data from the sample SSIs, a structured questionnaire is designed. The questionnaire sought information on identification particulars, details of current operation, fixed investment, production, exports and imports, recurring expenditure, subsidies availed; reservation and de-reservation policy for SSIs; OGL policy; removal of ORs; competition in exports and from imports; and membership and role of industry associations. WTO-related questions focused on awareness and impact of WTO. In particular, these questions to respondent-industrialists are listed in Box 1.

The study was carried out in Bangalore Urban district during April 2002. The questionnaire was canvassed through direct and personal interview method by trained investigators.

Initially, as per the above Mid Term Export Strategy, two units were planned to be sampled for each of the focus products. Thus, the total sample size was fixed at 42 units. The help of field officers of the Department of Industries, area industry associations, export promotion councils and individual entrepreneurs was sought to identify the units.

However, a strict identification of the above product-wise units is found to be impractical for many reasons. Consequently, alternative ways of reorganising products by deletion and regrouping are tried, as detailed below. First, Auto components, Hand Tools, IC engines and parts and Industrial Castings and Forging are clubbed to form engineering products Second, mango pulp is

Table 1: Summary of major surveys and seminars on WTO and SSIs in India

Title of the study	Sectors covered	Major findings, especially on factors which influence competitiveness in production/exports
1. Impact of Globalisation on Enhancing International Competitiveness of Indian Small Scale Industries – March 2000 – Ministry of SSI, Govt. of India	(a) Automotive components	Lack of demand, high local taxes, high overhead costs, non-availability of adequate inputs, obsolete technology, inadequate institutional credit and market support
Sample size: 602 units, spread over 7 states, viz., Delhi, Maharashtra, West Bengal, Punjab, Utter Pradesh, Tamil Nadu, Haryana and Andhra Pradesh	(b) Electronic components	Inadequate infrastructure, such as, lack of electric power and market information
	(c) Leather Footwear and Goods	Reduced local demand, high overhead expenditure, high local taxes, global recession, infrastructure bottlenecks and cumbersome procedures
Not WHO focused	(d) Readymade Garments	Global recession, foreign competition, inadequate power supply, lack of market information and low productivity
	(e) Preserved Fruits and Vegetables	Non-competitive prices, sluggish demand, high overhead expenditure, high local taxes, lack of information about markets and inappropriate packaging
	(f) Bicycle components	High competition in quality and prices, shortage of power, funds and delayed payments
	(g) Electric mixers and grinders	Entry of foreign brands with better quality and technology, lack of coordination between DICs and electricity department
	(h) Hand Tools	High cost of raw materials and cost of upgrading technology
2. Impact of Liberalisation and Globalisation on SMEs, February 2001 – World Trade Centre, Mumbai	Bulk drugs and dyestuffs	Competitive advantages for India: availability of skilled and low cost manpower, ability to produce quality drugs and lower cost of production
		Competitive disadvantages for India: Price undercutting (e.g. cheap imports from China), inability to market internationally, a lack of professionalism, and new patent regime
WTO focused		Depressed global market demand, slow down in textile industry, changes in consumption pattern and inconsistent quality for dyestuffs industry
		Lack of international quality, global reach, R&D spending and awareness of changes taking place in the market
		WTO patent laws would provide opportunities in terms of contract research, contract manufacturing, marketing tie-ups with MNCs and purchasing Exclusive Marketing Rights for Indian bulk drug producers
		ISO certification would be an almost mandatory requirement in post WTO era
3. SIDBI Seminars on Emerging Needs of SSI Sector-2000-01	All sectors	Issues pertaining to Central government:
20 centres all over the country		Definition of SSI, legal framework, labour laws, excise exemptions, Delayed Payment Act, technology upgradation and financial support
Participants included different stakeholders including Central and State government officials		Issues pertaining to State governments
		Infrastructure, Sales Tax and Administrative set up
Not WTO focused		
4. SIDBI Survey on "Emerging Needs of the SSI Sector"-2000-01	All sectors	Opinion (i.e. on desired changes, availability, and scope for improvement) of the associations on investment limit, fiscal policy, trade policy, infrastructure facilities, credit dispensation, linkage between small and large industries, technology, marketing, R&D facilities and role of SIDBI are reported.
Respondents: 100 industry associations		About 47 per cent of associations have reported that only 25 per cent of their members possessed marginal knowledge of the WTO agreements.
WTO focused		On WTO: Per cent of industry associations who opined that the following policy measures have favourable or no impact on their members:
		Reduction in tariff (favourable impact: 30%: and no impact 8%); Phasing out of QRs (15%: 12%); Existence of TBTs (19%: 14%); Patenting of products (32%: 6%); Availability of extended products (75%: 14%); Social clause and core labour standards (27%: 13%); Strict environmental norms (38%: 8%); Quality standardisation norms (68%: 7%); Anti-dumping measures (56%: 13%); Rules of origin (35%: 29%) and IT agreements (75%: 9%).

Source: Compiled by the author from SIDBI (2001).

Box 1: List of WTO-related questions in the sample survey questionnaire

- Are you aware of WTO and its agreements? If yes, please tell us the name of the agreements and their articles.
- Which of the agreements affect your product by exports and imports?
- Do you think that removal of QRs is due to WTO? If yes, what are the problems faced by your industry after removal of ORs?
- What are the various types of Non-tariff Barriers faced by three major destinations of exports?
- What are the extra efforts taken to adhere to the requirements of Non-Tariff Barriers in terms of money spent, delay in execution of shipment & additional experience required in-house?
- Whether your product is facing any problems pertaining to Sanitary and Phytosanitary Measures? If yes, give details.
- Whether dumping hurts your product? If yes, give details.
- Whether your product is facing problems pertaining to Pre-shipment Inspection in the importing countries? If yes, give details.
- Whether your product is facing tariff barriers in terms of high rate of tariffs? If yes, give details.
- What are the quality control measures adopted in your product to meet the requirements of WTO?
- What are the steps taken in your unit for securing international certification in compliance with WTO specifications?
- Indicate specific problems pertaining to WTO that has to be taken up with the Central Government?
- Are there any requirements to be met by the State Government for your industry to align with the WTO provisions? If yes, enumerate the input requirement.

Table 2: Actual and projected exports by select commodities relevant for SSIs in the Mid Term Export Strategy 2002-2007

Commodities	Actual exports in 2000-01 (US$ million)	Projected exports in 2006-07 (US$ million)	Projected exports as a percentage of actual exports
1. Leather and manufactures	1951 (3.86)	2614 (3.25)	33.98
2. Sports goods	68 (0.13)	78 (0.10)	14.71
3. Chemical & allied products	6265 (12.40)	11443 (14.22)	82.65
4. Engineering goods	5835 (11.55)	9564 (11.88)	63.91
5. Electronic goods	1141 (2.26)	1676 (2.08)	46.89
6. Textiles	12060 (23.86)	18311 (22.75)	51.83
Total (1-6)	12060 (54.06)	43686 (54.28)	59.90
Total for all commodities	50536 (100.00)	80480 (100.00)	59.25

Source: Computed by the author from Medium Term Export Strategy, Ministry of industry and Commerce, Government of India, 2001, as reported in the Economic Survey 2001-02, Government of India (2002): p. 137.

clubbed with Tropical fruit juice. Third, RMG cotton, including accessories and RMG of other textile materials are merged and made to form a single product. Fourth, electric power generation and distribution systems and electronics and precision engineering are merged to form a single product. Fifth, preserved mushrooms and RMG wool are deleted as they are not relevant for the study area.

Consequently, the total number of products is reduced to 13, and the total sample size is reduced to 26 units.

Description of survey data

Table 3 through Table 9 describe the quantitative and qualitative data of the sample survey. In all the tables, results are presented for 26 sample units as a whole.

Table 3 presents the current general characteristics of sample SSIs. First, the manufacturing units are largest in number as compared to ancillary and manufacturing-cum-ancillary units. Second, 73.07 per cent of units were established before 1996. Third, perennial operations dominate over seasonal operations. Fourth, in terms of ownership, limited companies are largest in number as compared to proprietary and partnership companies. Fifth, registration status indicates that registration with the State Department of Industries and Commerce is highest. This is followed by registration with sales tax department, Factory Act and Central Excise. Sixth, of the total employees, the share of workers is about 87 per cent. Seventh, membership to industry associations show that KASSIA's membership dominate over membership to local industry associations and product associations.

Table 4 highlights the investment details of sample SSIs. All investment patterns in the table refer to cumulative investment up to 2001-02 current prices. Of the types of investment, investment on testing and quality control account for about 66 per cent. Next, fixed investment on plant and machinery (21.74 per cent) and investment on land and buildings (8.64 per cent) constitute a remarkable share in total investment.

In Table 5, the pattern of recurring expenditure from 1998-99 to 2001-02 is presented. The most important recurring expenditure is on purchase of raw materials (about 77 per cent). This is followed by payment of wages and salaries for employees (about 9 per cent), payment of taxes to central and state government (about 3 per cent) and rent on land and building (about 3 per cent). Power and transport charges account for about 2 per cent of total recurring expenditure.

Table 3: General characteristics of sample SSI units in Bangalore Urban District: April-May, 2002

Sl. No.	Characteristics	Per cent of total units
1.	Nature of unit	
	1.1. Manufacturing	61.6
	1.2. Ancillary	19.2
	1.3. Both	19.2
2.	Nature of operation	
	2.1. Perennial	92.3
	2.2. Seasonal	7.7
3.	Type of ownership	
	3.1. Proprietary	34.6
	3.2. Partnership	19.2
	3.3. Limited company	46.2
4.	Accounts maintained	100
5.	Registration status	
	5.1. Factory Act	57.69
	5.2. Dept of Industries and Commerce	96.15
	5.3. National Small Industries Corporation	11.54
	5.4. Karnataka State Pollution Control Board	38.46
	5.5. Central Excise	53.85
	5.6. State's Sales Tax	88.46
6.	Total number of staff	1784
	6.1. Workers	87.33
7.	Member of industrial association/s	
	7.1. Karnataka State Small Industry Association (KASSIA)	73
	7.2. Local Industrial Associations	62
	7.3. Industrial Product Associations	58

Source: Compiled from the Pilot Study of SSIs in Bangalore Urban district, conducted during April-May 2002, for the study in Narayana (2003).

Table 4: Patterns of cumulative investment by sample SSIs of Bangalore Urban District up to April-May, 2002

Characteristics	Per cent of total investment
Original investment on plant & machinery	21.74
Investment on land and buildings	8.64
Investment on technology upgradation	1.70
Investment on pollution control equipment	0.16
Investment on certification (e.g. ISO9000)	1.28
Investment on testing and quality control	66.38
Total investment (Rs. in lakh at current prices)	100.00 (11604)

Source: Same as in Table 3.

Table 5: Pattern of recurring expenditure of sample SSIs in Bangalore Urban district: 1998-99 to 2000-01

	Per cent to total recurring expenditure		
	1998-99	1999-00	2000-01
Raw materials	79.01	78.60	76.63
Total wage bill for workers and/or managerial staff	9.11	9.52	10.57
Power charges	1.33	1.44	1.53
Water charges	0.39	0.40	0.41
Debt servicing (repayment of principal amount and/or interest charges)	2.74	2.86	3.22
Taxes paid including for central taxes, state taxes and local areas	3.08	3.05	2.88
Rent on land and buildings	0.17	0.20	0.34
Transportation charges	2.12	2.20	2.21
Paper, printing and stationery	0.08	0.17	0.28
Fuel expenses	0.31	0.48	0.66
Other expenses	1.15	1.18	1.27
Total recurring expenditure (Rs. in lakh at current prices)	100.00 (9093)	100.00 (9899)	100.00 (10970)

Source: Same as in Table 3.

Table 6: Pattern of production, exports and imports of sample SSIs in Bangalore Urban district: 1998-99 to 2000-01

Performance indicators	1998-99	1999-00	2000-01
1. Total output/sales (Rs. in lakh)	9901	14126	11452
2. Share of exports and total output (%)	51.11	61.60	34.87
3. Total imports (Rs. in lakh)	1344	1345	1736
4. Share of imports in total output (%)	13.47	9.52	15.16
5. Total output per worker (Rs. in lakh)	6.35	9.07	7.35
6. Total output per employee (Rs. in lakh)	5.55	7.92	6.42

Notes:

1. All figures are at current prices.
2. Total output is the sum of total domestic sales and exports.
3. Total employees are the sum of workers and management and supervisory staff.
4. Data on total number of staff is for 2000-01, and is assumed to be the same for all the years.

Source: Same as in Table 3.

Table 6 presents the pattern of production/output/total sales, exports and imports of sample units from 1998-99 to 2001-02 and at current prices. Total output has increased from Rs. 9901 lakh to Rs. 11452 lakh in

2001-02. The share of exports (or imports) in total output has fluctuated from 51.11 (or 13.47) per cent in 1998-99 to 61.6 (9.52) per cent in 1999-00 and to 34.87 (15.16) per cent in 2001-02. Along with the increase to total output and exports, total output per worker or employee (a measure of labour productivity) has increased from Rs. 6.35 lakh in 1998-99 to Rs. 9.07 lakh in 1999-00, but declined to Rs. 7.35 lakh in 2001-02.

Table 7 summarises the subsidies and concessions availed by the sample SSIs up to April 2002. It is evident that sales tax concessions are availed most, followed by the receipt of capital investment subsidy from the state government.

Table 7: Subsidies and concessions availed from the State Government by sample SSIs in Bangalore Urban district: 1998-99 to 2001-02

Subsidies and concessions	Percent to total subsidies and concessions availed
Capital subsidy from the State Government	0.71
Capital subsidy from the Central Government	6.23
Sales tax concessions	84.02
Stamp duty and registration charges	0.10
Total subsidies and concessions (Rs. in lakh at current prices)	100.00 (288.7)

Source: Same as in Table 3.

Table 8: Awareness of reservation policy, removal of QRs and WTO agreements among the proprietors of sample SSIs in Bangalore Urban district: April-May, 2002

Awareness Indicators	Extent of awareness (%)
Reservation policy for SSIs	80.80
De-reservation policy for SSIs	57.70
One's own product comes under reserved list	50.00
One's own product comes under de-reserved list	30.80
SSI product is put under OGL	84.60
One's own products are put under OGL	65.40
SSI products are subject to removal of QRs on imports	76.90
WTO and its agreements	84.60
Removal of QRs is due to WTO commitments	76.90

Source: Same as in Table 3.

Awareness of reservation and dereservation policies, removal of ORs and WTO agreements among the sample SSIs are presented in Table 8. Awareness is indicated to be highest with regard to WTO and its agreements. In the same way, awareness is high with regard to reservation policy for SSIs, SSI products on OGL and subject to removal of QRs, and removal of QRs due to WTO commitments.

Table 9 presents the awareness of sample SSIs on the nature and source of competition and trade barriers. Of the nature of competition, (a) awareness is highest on facing competition from large and medium scale industries from outside the state and (b) awareness is least on facing competition due to removal of QRs on SSI products. Although awareness on facing competition since 1995 is high, there is lack of awareness on facing problems due to implementation of different WTO agreements (e.g. SPS, TBT) and on facing NTBs.

Box 2: Response of sample SSIs on measures to be taken by Central and State government

Central Government

- Protection from MNCs
- Create monitoring cell for quality and prices of domestic products
- Create monitoring cell for quality and price of imported goods
- Training, seminars and circulars on WTO and international marketing
- Import duty to be reduced
- CST to be removed
- Investment on R&D to increase productivity
- Transfer of technology to enhance competitiveness
- Quick payment of duty-drawbacks

State Government

- Provision of infrastructure facilities, such as adequate and reliable power supply
- Establishment of Special Economic Zones
- Monitoring of dumping activities
- Awareness on WTO agreements and their impact
- Avoid frequent inspections
- All Government procurement from SSIs
- Protective measures to be continued for a few more years
- Direct financial support to new SSIs
- Regular flow of information on changes in regulations, concessions, subsidies, facilities, seminars, etc. in both English and the local language

On the specific measures to be undertaken by the central and state government, the response of sample SSIs are many and diversified. These responses are summarised in Box 2.

Additional insights from the survey

During the survey, the respondents are probed on

Table 9: Nature and source of current competition and trade barriers faced by sample SSIs in Bangalore Urban district: April-May, 2002

Sl. No.	Nature and sources of competition and trade barriers for one's own product	Percent of responses		
		Yes	No	Don't Know
1.	Nature of competition			
	1.1. Facing competition from large and medium scale industries within the State	46.20	53.80	0.00
	1.2. Facing competition from large and medium scale industries outside the State	67.70	32.30	0.00
	1.3. Facing competition due to introduction of OGL policy for SSI products	34.60	65.40	0.00
	1.4. Facing competition due to removal of QRs on SSI products	26.90	69.20	3.90
2.	Nature of trade barriers			
	2.1. Facing new competition since 1995 or establishment of WTO	88.50	11.50	0.00
	2.2. Facing sanitary and phytosanitary barriers in exporting	23.10	76.90	0.00
	2.3. Facing the problem of dumping from foreign producers in domestic markets	30.80	69.20	0.00
	2.4. Facing the problem of pre-shipment inspections in exporting	3.60	88.50	7.90
	2.5. Facing the problem of tariff barriers in exporting	7.70	84.60	7.70

Source: Same as in Table 3.

their awareness of the nature and impact of WTO agreements, beyond their categorical responses to the questions in the questionnaire. The additional insights from the probing are summarised below:

- In general, unaware of specific agreements and their articles. Thus, no idea on the effect of agreements by exports and imports. An important reason for this unawareness is that most of the sample SSIs are not direct exporters of their products.
- Problems faced after removal of QRs are in the form of price competition, fear of losses and unhealthy competition.
- Not faced with NTBs in export destinations. Thus, no extra efforts taken to adhere to the requirements of NTBs.
- No idea on problems pertaining to SPM and Pre-shipment inspection.
- Not clear about dumping problem. In general, sale of imported goods at low price and low quality is confused with dumping.
- No quality control measures adopted in compliance with WTO, although most units are conscious of the quality of their product and adopt in-house voluntary quality control measures in response to customer needs. Nevertheless, generally aware of ISO-9001.

In essence, the above additional insights imply lack of knowledge and awareness on the nature and impact of WTO agreements by sample SSIs. In a way, this nullifies the descriptive analysis on quantified categorical response data on awareness and impact indicators, as in Table 8 and Table 9 above.

Conclusions

This paper has provided a simple framework for the collection and description of primary data on performance of manufacturing SSIs under the WTO regime within a state in India. The implementation of this framework for Bangalore Urban district has ascertained the availability and accessibility of quantitative and qualitative data on WTO-related matters at the unit level. Consequently, the lessons of this study are relevant for the design and conduct of future studies on WTO-related studies on SSIs in the state in particular and in other states in general.

The major conclusions and implications of this paper are as follows:

First, awareness and knowledge on WTO agreements are limited among the sample SSIs. This prevents the sample SSIs from self-assessment of the nature and impact of WTO agreements on their products. Thus, the SSIs may not prepare themselves well to exploit the trading opportunities and meet the challenges under the WTO regime. To overcome this problem, SSIs should be provided with both awareness and knowledge on the nature and impact of WTO agreements in the products that they manufacture and market in and outside the country. This suggests that product-wise analysis of the impact of WTO agreements is essential for the benefit of SSIs.

Second, this study has demonstrated that probing of SSIs is insightful to understand the true awareness and knowledge of SSIs on WTO-related matters. Thus, a mere description of categorical responses on the awareness and knowledge of SSIs on WTO may lead to misleading conclusions and implications.

Third, this paper has shown that the export targets of Mid Term Export Strategy 2002-07 of the Government of India is dependent, among others, on the export performance of SSIs. To accomplish these targets, SSIs must be prepared to exploit the available and future opportunities for export trade, as per the trading arrangements of India with other countries. These trading arrangements include bilateral, regional and multilateral trade agreements under the WTO. Thus, in essence, SSIs must be prepared to perform in globally competitive ways in order to accomplish the targets of the Mid Term Export Strategy.

Fourth, this study has taught that all quantitative data are collectable, both quickly and completely, from the sample units if the data are relevant for the current financial year. This is due to poor maintenance of records or lack of access to information from past record books. Thus, time series data on performance indicators should not be included in short term and time-bound surveys of SSIs in the state.

Fifth, for a comprehensive study of SSIs under the WTO regime, the design and scope of the questionnaire should be enlarged to include, for instance, the nature and quality of infrastructure facilities available for SSIs in different focus products. This shall help in identifying the specific factors, which influence their competitiveness, and in drawing specific suggestions for enhancing and strengthening their competitiveness under the WTO regime.

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The world hates changes, yet it is the only thing that has brought progress.

– Charles F. Kettering

Feature

Contract Farming in Punjab

P.S. Rangi & M.S. Sidhu

This paper examines policy issues pertaining to the contract farming system in the Punjab State scheme. Farmers involved in this scheme were informally interviewed to establish the need for contract farming, shifts in cropping patterns and the yield and returns from different crops.

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The basic concept of the contract farming system is to reduce risks for the buyers and producers of a product. To cover their risks, both the producers and the buyers – mainly processors, enter into contracts to supply or purchase a specified quantum of the commodity at pre-determined or agreed prices over a period of time. The agreed contract sometimes covers the mode and time of payment, credit facilities, input supply, etc and may be either formal or informal (Bhalla and Singh, 1996). By contracting, the buyer reduces the risk of non-availability of raw material and the producer also reduces risk, as a fixed price contract for a given area eliminates the market risk of a grower (Glover, 1990).

The scope for development of contract farming lies in the development of agro-processing industries and related infrastructure. The vastness of India with diversity in its agro-climatic conditions confers comparative advantage in production of most of the high value crops. Most of the developed countries are deprived of this gift of nature, and crops like fruits, vegetables and flowers are cultivated in green houses at a very high cost (Haque and Birthal, 1998). India is the second largest producer of fruits and vegetables in the world (Government of India, 2002). The commercial processing of fruits and vegetables in our country is hardly about two per cent. Against this, the commercial processing is about 70 per cent for Brazil, 83 per cent for Malaysia, 70 per cent for Philippines and 30 per cent for Thailand (Rangi and Sidhu, 2000). As a result of poor agro-processing infrastructure, 25 to 30 per cent of the total production is lost every year (Ibid). The processing of farm produce increases its value; i.e. it adds form utility. During 2002, the Punjab Government and its public sector organisations initiated a number of steps to popularize the contract farming scheme. It has been given wide publicity in the newspapers and electronic media. In this paper, an attempt has been made to examine some policy issues of the contract farming system in the Punjab State scheme.

Data base

The paper is based on data published by reputed sources. The Punjab Agro-Foodgrain Corporation Ltd., Chandigarh, has given a number of advertisements in the newspapers related with contract farming in the State. The data published in such advertisements have also been used. A cross-section of farmers involved in this scheme were informally interviewed during field visits. Similarly, such farmers visiting PAU were also informally interviewed regarding this scheme.

Results and discussion

Need for contract farming

During the last three decades or so, the cropping pattern in the State has witnessed a distinct shift in favour of paddy-wheat rotation, creating some serious imbalances in the farm production pattern accompanied by several related problems on production, market and input supply fronts. The predominance of paddy-wheat rotation has some far-reaching implications for the State in the form of soil health, multiplication of pests and diseases, intensive use of energy, particularly commercial energy and deterioration in the overall agro-eco-system of the State (Johl et al. 1986). The Expert Committee on Diversification of Agriculture in Punjab (popularly known as Johl Committee) recommended in 1986 that at least 20 per cent of the area presently under wheat and paddy must be replaced by other competitive and profitable alternative farm enterprises. Only then, the diversification would have any perceptible impact on the economy of the State. Due to various reasons, the recommendations of the Johl Committee (1986) were not accepted by the Government of India as well as the Punjab Government although the policy makers, planners, administrators and agricultural scientists talked about the need for diversification of agriculture.

Keeping in view all these aspects the State Government again constituted a committee after a gap of 16 years under the Chairmanship of Dr S.S. Johl, an internationally known agricultural economist in the year 2002. Again, this Chief Minister's Advisory Committee on Agriculture Policy on Restructuring recommended that ten lakh hectares of area under wheat and paddy rotation should be replaced by other crops which consume less water, are compatible ecologically and are in demand in the country (Johl, et al 2002). For this purpose, the Government of India may give cash compensation @ Rs. 12,500 per hectare to the state farmers. This target of shifting one million hectares of land from under rice-wheat rotation to other crops can be achieved at the cost of Rs 1280 crores by providing compensation to the farmers for not growing rice and wheat and shifting the area to other crops (Ibid). The recommendations of the Johl Committee-II are still in the pipeline and the Government of India has taken no final decision so far in this regard. Some people say the report on diversification has been placed in bureaucratic deep freeze at the capital level (Gill, 2003).

Wheat and paddy rotation should be replaced by other crops which consume less water, are compatible ecologically and are in demand in the country.

The farm income in Punjab started improving with the introduction of high yielding varieties (HYVs) of wheat in the mid-sixties and HYVs of paddy in the early seventies. Since the mid-eighties, the real income of the farmers did not show any remarkable increase due to stagnation in farm productivity (Rangi and Sidhu, 1999). Rather, there is decline in cotton productivity during the last one decade or so. For these reasons, further improvement in farm income has become increasingly difficult. In fact, it would be a great challenge even to maintain the real farm income at the present level in the coming years. Above all, the total indebtedness of the Punjab farmers was around Rs 5700 crore in 1996-97 (Shergill, 1998). A number of farmers committed suicide in the State in recent years due to severe economic crisis, particularly indebtedness.

Shifts in cropping patterns

The cropping pattern in the State is shown in Table 1. The figures show that during the year 2001-02, about 78 per cent of the total cropped area was under foodgrains, about 11 per cent under cash crops, i.e., cotton, sugarcane, oilseeds and potato and 1.8 per cent was occupied by fruits and vegetables. Per cent area under cereals increased from about 51 per cent in 1966-67 to about 77 per cent in 2001-02. It may be mentioned here that wheat alone occupied about 43 per cent of the total cropped area in this year. Similarly, rice crop had about 31 per cent of the total area. In this way, both wheat and paddy occupied about 74 per cent of the cropped area. All other cereal crops like maize, jowar, bajra, barley, etc. had only about three per cent of the cropped area. On the other hand, the area under pulses declined from 13.4 per cent in 1966-67 to only 0.6 per cent in 2001-02. Similarly, the area under oilseeds declined from 6.2 per cent to 1.0 per cent, sugarcane from 3.0 per cent to 1.8 per cent and cotton from 8.4 per

Table 1: Shifts in cropping pattern in Punjab, 1966-67 to 2001-02

(%age area under crop)

Year	Cereals	Pulses	Foodgrains	Oil-seeds	Sugarcane	Potato	Cotton	Fruits and vegetables
1966-67	50.9	13.4	64.3	6.2	3.0	0.3	8.4	0.8
1971-72	61.9	6.7	68.6	5.6	1.8	0.8	8.5	0.8
1976-77	64.7	6.3	71.0	4.0	1.8	0.5	8.8	0.7
1981-82	67.5	4.7	72.2	3.2	1.5	0.5	9.9	1.3
1986-87	73.5	3.1	76.6	2.3	1.5	0.4	8.7	1.8
1991-92	73.8	1.2	75.0	2.8	1.5	0.4	9.6	1.8
1996-97	71.6	1.2	72.9	3.1	2.2	0.6	9.2	2.1
2001-02	76.9	0.6	77.5	1.0	1.8	0.7	7.6	1.8

Source: Statistical Abstract of Punjab for various years.

cent to 7.6 per cent in the corresponding period. The area under cotton was fluctuating in the last decade as the attack of the American bollworm on the cotton crop adversely affected the production and productivity of this crop in the State. Under these circumstances, some area under cotton shifted to paddy on account of stable yield and assured price for paddy crop. The area under fruits and vegetables increased from 0.8 per cent in 1966-67 to 1.8 per cent in 2001-02. This shift has not been significant although fruits and vegetables earn 20 to 30 per cent times more foreign exchange per unit area than cereals (Dahiya, 1999). This analysis reveals that cereals, particularly wheat and rice, have come to dominate the cropping pattern in the State in the wake of new farm technology and the axe has fallen mainly on pulses and oilseeds.

Contract farming plan, 2003 to 2007

The Punjab Agro Foodgrain Corporation has prepared a plan to promote contract farming in four lack acres in the year 2003, nine lakh acres in 2004, 13 lakh acres in 2005, 18 lakh acres in 2006 and 25 lakh acres in 2007 (Table 2). The major thrust has been on kharif corn followed by durum wheat and hyola. Basmati rice and sunflower are two other important crops covered in this scheme. It may be mentioned here that vegetable crops are labour intensive and can provide 4-5 times more employment opportunities as compared to wheat and paddy crops. At the same time, about 45 per cent of the operational holdings in Punjab consist of small and marginal farmers. A look at the contract-farming plan indicates that less importance has been given to the vegetable crops due to their perishable nature. The price fluctuation are also more for vegetable crops. In this way, the policy makers of this scheme have ignored vegetable cultivation. Even in the year 2007, the area under contract farming for vegetable crops will be only 20 thousand acres, i.e. a very small figure of only 1.61 acres per village of the State.

Vegetable crops are labour intensive and can provide 4-5 times more employment opportunities as compared to wheat and paddy crops.

Another aspect that has been ignored in the contract-farming plan is the seed. The seed requirement for a single durum wheat crop has been estimated at about 0.40 lakh qtls in 2003, 0.80 lakh qtls in 2004, 1.20 lakh qtls in 2005, 1.60 lakh qtls in 2006 and 2.00 lakh qtls in 2007. The seed supply management has been properly formulated.

Already, the winter maize crop, particularly in Nawan Shahar district, has totally failed under contract farming during the year 2002-03. The Agriculture Minister of Punjab has already ordered an enquiry into the failure of winter maize grown under contract farming after the farmers protested in this regard (Singh, 2003). At the same time, the Punjab Government had kept the Punjab Agricultural University and agriculture technocrats out of the picture, which is not good (Sidhu, 2003). The private companies have a run of Punjab's fields with no check on seed quality, gene pool safety or legal safeguards for farmers (Ibid.) It has been found that caster oil seed and cotton are confirmed enemies of each other and the farmers spent years getting caster oil seed out of the Malwa region of the State but Punjab Agro Foodgrain Corporation is now recommending the sowing of crop in the cotton belt (Fazilka) under a new scheme. For castor/jastropha, the proposed plan is five thousand areas in 2003, ten thousand areas in 2004, 20

Table 2: Contract farming plan for the year 2003-2007

	Target plan in acres				
Crop	2003	2004	2005	2006	2007
Hyola	75000(18.75)	200000(22.2)	300000(23.7)	400000(22.2)	500000(20.00)
Barley	5000(1.25)	15000(1.66)	25000(1.92)	400000(2.22)	70000(2.80)
Winter maize	3000(6.75)	5000(0.55)	11000(0.84)	12500(0.69)	15000(0.60)
Durum wheat	100000(25.00)	200000(22.22)	300000(23.07)	400000(22.22)	500000(20.00)
Sunflower	12500(3.12)	40000(4.44)	100000(7.69)	150000(8.33)	225000(9.00)
Spring corn	5000(1.25)	15000(1.66)	15000(1.15)	400000(2.22)	80000(3.20)
Basmati	25000(6.25)	50000(0.55)	70000(5.38)	100000(5.55)	150000(6.00)
Kharif corn	150000(37.5)	300000(33.33)	400000(30.76)	500000(27.77)	700000(28.00)
Guar gum	5000(1.25)	6000(0.66)	7500(0.57)	10000(0.55)	14500(0.58)
Castor/Jastropha	5000(1.25)	10000(1.11)	20000(1.53)	40000(2.22)	50000(2.00)
Groundnut	1000(0.25)	1500(0.16)	15000(1.15)	20000(1.11)	25000(1.00)
Organic basmati	1000(0.25)	3000(0.33)	5000(0.38)	7000(0.38)	15000(0.60)
Vegetables	2000(0.50)	4000(0.44)	6000(0.46)	10000(0.55)	20000(0.80)
Others	10500(2.62)	50500(5.61)	25500(1.96)	70500(3.91)	135500(5.42)
Total	400000(100.00)	900000(100.00)	1300000(100.00)	1800000(100.00)	2500000(100.00)

Note: Figures in parentheses indicate percentages to total.

Source: Punjab Agro Foodgrain Corporation Ltd., Chandigarh.

Table 3: Area, yield and returns of Hyola crop under contract farming in Punjab, 2002-03

District	Area (acres)	Farmers (No.)	Yield per acre (qtls)			Return per acre (Rs)	Market price (Rs/qt)	
			Highest	Lowest	Mean		Range	Average
Amritsar	1147	425	8	3	6	11000	1600-2100	1850
Bathinda	545	193	9	6	6.7	12663	1785-2000	1890
Faridkot	500	193	9	5	7.4	12950	1700-1800	1750
Fatehgrarh Sahib	370	267	8.5	5.0	7	13300	1800-2000	1900
Ferozepur	901	124	8.0	4.5	6	11340	1857-1920	1890
Gurdaspur	825	532	9	6	6.9	13697	1900-2100	1985
Hoshiarpur	473	250	11	4	6	19920	1550-2000	1820
Jalandhar	429	121	7.5	6.0	7.1	12354	1600-1880	1740
Kapurthala	305	95	8	3	4.6	10440	1600-1700	1650
Ludhiana	1457	93	10	6	7.8	14235	1650-2000	1825
Mansa	240	113	10	2.5	7.0	12180	1650-2000	1740
Moga	230	129	7	4.5	5.8	10440	1700-1900	1800
Mukatsar	533	162	8	4.5	6.8	12444	1775-1900	1830
Nawanshahar	484	212	8	5	6.05	10436	1640-1850	1725
Patiala	435	401	8	5	6.5	12350	1700-2100	1900
Ropar	201	150	7.5	4	4.75	7671	1500-1800	1615
Sangrur	723	482	9	4	7	1330	1700-2100	1900
Total/Mean	9798	3924	8.55	4.59	6.44	11872	1500-2100	1812

Source: Punjab Agro Foodgrains Corporation Ltd., Chandigarh.

Table 4: Area, yield and returns of barley (UJM-315) crop under the contract farming in Punjab, 2002-03

District	Acres	No. of farmers	Yield per acre (qtl)			Return per acre (Rs)	Market price (Rs/qtl)	
			Highest	Lowest	Mean		Range	Average
Sangrur	549	251	19	12	15.5	8660	500-590	560
Patiala	291	130	22	12	17	9520	536-579	560
Total	840	381	20.5	12	16.25	9090	500-590	560

Source: Punjab Agro Foodgrain Corporation Ltd., Chandigarh.

thousand acres in 2005, 40 thousand acres in 2006 and 50 thousand areas in 2007.

Area, yield and returns of hyola crop

The information regarding area, yield and returns of hyola crop under contract farming in Punjab during the year 2002-03 is shown in Table 3. The area under contract farming was 9798 acres against the original proposal of 20 thousand acres. The maximum area was in Ludhiana district (1457 acres) followed by Amritsar district (1147 acres), Ferozepur district (901 acres), Gurdaspur district (825 acres) and Sangrur district (723 acres). The lowest area was in Ropar district (201 acres), Moga and Mansa districts had also 230 acres and 240 acres, respectively, under hyola crop. The average area per district was about 576 acres. The total number of farms covered under the contract farming programme for hyola crop was 3924, which means about 231 farmers in each district. The average area per farmer in the State was about 2.50 acres. The maximum yield obtained was 8.55 qtls per acre. Against this, the lowest yield was 4.59 qtls per acre. The average yields of hyola crop realized by contract farming was 6.44 qtls per acre which gave an average return of Rs 11872 per acre during the year 2002-03. The average price received by the contract farmers was about Rs 1843 per qtl.

The Punjab Agro Foodgrain Corporation has claimed that the farmers' returns were Rs 2000 to Rs 4000 per acre higher from the hyola crop as compared to wheat but in reality the returns from the wheat crop were about Rs 14700 per acre as against Rs 11872 from the hyola crop. In this way, the wheat crop gave additional returns to the Punjab farmers to the extent of Rs 2828 per acre. The dairy sector, which plays an important role in the Punjab economy, particularly in the rural areas, gets the wheat bhusa from the wheat crop. It is the main dry fodder for the milch and dry animals in the State. The hyola crop cannot serve the dairy sector of the State on a large scale. As for the claims of PAFC regarding unprecedented weather in the winter season of 2002-03, it has affcted the yield of all the crops whether grown under contract farming or not. Therefore, the claims of the PAFC regarding low yield of hyola on account of weather have no sound basis.

Area, yield and returns of barley crop

The information regarding area, yield and returns of barley crop under contract farming in the year 2002-03 is given in Table 4. The total area under barley was 840 acres, out of which about 65 per cent (549 acres) was in Sangrur district and about 35 per cent (291 acres) in Patiala district. Originally, the area proposed for barley was one thousand acres during the rabi season, 2002-03. The number of farmers covered under this scheme was 381 out of which 251 farmers were from Sangrur district and the rest 130 farmers were from Patiala district. The area per farmer was 2.20 acres under barley crop. The average yield of barley was 16.25 qtls per acre. The highest and lowest yield was 20.5 qtls and 12 qtls, respectively. The farmers of Patiala district got a high yield, i.e., 17 qtls per acre as compared to 15.5 qtls per acre in Sangrur district. The yield was higher in Patiala district on account of better management of the crop by the farmers. The returns were to the extent of Rs 9090 per acre. Since yield of barley was higher in Patiala district, therefore, the returns were also high to the extent of Rs 860 per acre in this district. The average price of the crop was Rs 560 per qtl.

Yield and returns of peas

The information regarding yield and returns from peas crop is given in Table 5. According to the press reports, the area under peas was around 500 acres in Patiala and Fatehgarh Sahib district (Singh, 2003). Originally, the area proposed for vegetable crops was one thousand acres in the rabi season, 2002-03. The number of farmers involved for this vegetable crop was 52. The highest yield of the crop was 5632 kgs per acre. Similarly, the highest returns were Rs 39424 per acre. Therefore, the highest price given for green peas was Rs 7.00 per kg. The contract farmers from Patiala and Fatehgarh Sahib districts were forced to dump their produce in the local mandis after rejection by the agro-agency (Ibid). Though the officials of Punjab Agro were of the opinion that the green peas grown by contract farmers of both districts were rejected due to spread of

fungus infection due to inclement weather. The farmers felt that the quality peas were rejected making them deeply suspicious of the contract farming scheme initiated in the State under which agencies like Punjab Agro had given certified seed to the farmers on the promise that their crop would be procured at pre-determined rates (Ibid).

Table 5: Area, yield and returns of peas under contract farming in Punjab, 2002-03

District	Farmers involved	Yield/acre (kgs)	Return/acre (Rs)
		Highest	Highest
Patiala and Fatehgarh Sahib	52	5632	39424

Source: Punjab Agro Foodgrain Corporation Ltd., Chandigarh.

Issues involved in contract farming

Although it is not appropriate to comment upon the performance of the scheme since it is only one year old some basic deficiencies prevail in the system. The PAFC does not have technical manpower for growing agricultural products but depends upon consultants and various companies like Mahindra and Mahindra, Escorts, Sri Ram (DCM), KBRL, Pepsi, etc. Most of these companies lack such experience in Punjab. A long time-tested premier research institute like Punjab Agricultural University (PAU) has not been involved at any stage and the Department of Agriculture, Punjab, which has its roots up to the village level also have not been involved. For seed requirement and transfer of technical know-how, PAFC is dependent on MNCs for supplying seeds of the contracted crops and the input supplies in some of the crops. The agronomic practices and suitability of crop varieties is not tested so they may not perform as expected and also may be highly susceptible to insect-pests and diseases. Moreover, the companies entrusted with extension programmes are not aware of the ground realities of Punjab agriculture.

Further, it is a common complaint of the farmers that seed supplied by PAFC was not of good quality in case of winter maize. The seed supplied had not germinated and was later replaced at many places but did not yield good results. Though the crop germinated at some places and the plants were healthy the cobs in most of the cases remained unfilled. The farmers suffered heavily. The officials of PAFL blamed it on extreme cold weather but this was not the case for the winter maize grown with seeds supplied by PAU. Originally, the area proposed for winter maize was seven thousand acres in the year 2002-03. Basmati rice is being cultivated under the contract-farming scheme in the south-western districts of the State. This belt is not suitable for basmati rice cultivation. The quality of the rice grown in these districts may not be good. The traditional basmati rice growing districts are Amritsar, Gurdaspur and Kapurthala. The major thrust of the PAFC should be on these districts and in block plantation as far as basmati rice is concerned.

The traditional basmati rice growing districts are Amritsar, Gurdaspur and Kapurthala.

During the year 2003, the PAFC planned to grow durum wheat on one lakh acres. In the very first year, it is almost impossible to bring such a large area under the crop. The study conducted at PAU has revealed that the international prices of durum wheat are low and the Indian exporters are not in a position to compete with the bulk suppliers of USA, Canada, etc. in the international wheat market without direct financial support from the government at this point of time (Rangi and Sidhu, 2001a). The financial position of the Punjab Government is not very sound. Then the question arises who will provide subsidy to the exporters of durun wheat from Punjab. The private entrepreneurs always undertake the business with a profit motive. A study conducted at PAU has revealed that the wholesaler has to bear a loss of Rs 22 per qtl for sale of durum wheat at Hyderabad (Rangi and Sidhy, 2001b). The wholesaler had to bear the total cost, i.e. Rs 847 per qtl (including the price paid to farmers at Khanna market in Punjab). After bearing all the market charges, transportation and other miscellaneous expenses, the wheat was sold @ Rs 825 per qtl in Hyderabad (Ibid). In this way, the traders had to bear loss instead of profit. Already, Rajasthan and Madhya Pradesh are the two main suppliers of durum wheat to the southern states. The traders of these states also compete with Punjabi traders. The quality of durum wheat produced in these two states is also better in comparison to the durum wheat produced in Punjab. Therefore, the millers/traders of the southern states prefer the produce of Rajasthan and Madhya Pradesh. The transportation cost and market taxes borne by the traders of Punjab was also higher in comparison to their counterparts in the latter two states. These facts clearly indicate that our durum wheat is uncompetitive in the international as well as domestic market.

Contract farming is not legal in the State. The experience of Thailand and Turkey revealed that the introduction of the contract system had gone against the interests of the farmers in the absence of any ad-

ministrative and legal framework (Gill, 2003). In Thailand, procurement was entrusted to a multinational company. It proved to be disadvantageous to farmers (Ibid). In Turkey, the contract system was introduced for citrus. The absence of guided agronomic practices led to the depletion of the water table and soon fruit plants started drying and dying (Ibid). In order to avoid various problems related with fulfillment of the contract between the buying company and the farmers (sellers), such companies will have to given corporate and bank guarantees to ensure they finally pay what is promised. The State Government is also putting money on the table. It has announced, for the first time, a minimum support price of traditional basmati paddy and maize at which farmers can sell to state agencies if companies shy away (Srinivas, 2003). Whole basmati paddy will be procured at Rs 1100 per qtl., maize will be bought at Rs 500 per qtl (Ibid). The contract system is not legal but this decision of the State Government is praiseworthy because a minimum support price was assured to the farmers for atleast two crops in the kharif season of 2003.

A debate is going on for the last 17-18 years about diversification of agriculture in Punjab. But hardly any concrete step has been taken. Even the present contract farming system introduced in the state may not achieve the target of diversification of agriculture because most of the contracts for various crops are with those farmers who were already growing such crops. Therefore, it cannot be termed as a diversification endeavour in place of wheat-paddy cropping system. Moreover, the contract farming system is most successful all over the world for agro-processing and perishable commodities. The present half-hearted approach in the state may adversely affect the contract system itself in the long run. Above all, there is no need to bring such a large area of five lakh areas under durum wheat by the year 2007. Keeping in view the ground reality, we may start durum wheat with 20000 acres in 2003, 40000 acres in 2004, 60000 acres in 2005, 80000 acres in 2006 and 100000 acres in 2007. The modest increase in area every year will pose minimum problems. The area around Khanna mandi is most suitable for the cultivation of durum wheat in the State. At the same time, efforts may be made to encourage the setting up of agro-processing units in the State. The MNCs are already there. After the setting up of such units, the contract area for vegetable crops and fruits may be increased.

The contract farming system is most successful all over the world for agro-processing and perishable commodities.

Conclusion and suggestions

The basic concept of the contract farming system is to reduce risks for the buyers and the producers of a product. To cover their risks, both the producers and the buyers enter into contracts to supply or purchase a specified quantum of the commodity at predetermined or agreed prices over a period of time. During the last three decades or so, the cropping pattern in the state has witnessed a distinct shift in favour of paddy- wheat rotation, creating some serious imbalances in the farm production pattern accompanied by several related problems in production, market and input supply points. Keeping in view all these problems, the PAFC has prepared a plan to promote contract farming on a large scale in the State during the next five years. The major thrust has been on kharif corn followed by durum wheat and hyola. Basmati rice and sunflower are other two important crops covered in this scheme. A meagre importance has been given to vegetable crops due to their perishable nature. The price fluctuation is also more for vegetable crops. Even in the year 2007, the area under contract farming for vegetable crops will be 20000 acres i.e. a very small figure of only 1.61 acres per village of the State. The seed supply management has not been proper under this scheme. Already, the winter maize crop, particularly in Nawan Shahar district, has totally failed under contract farming during the year 2002-03. At the same time, Punjab Agro had kept the PAU and the agriculture technocrats out of the picture, which is not good. The private companies have a run of Punjab's fields with no check on seed quality, gene pool safety or legal safeguards for farmers.

It is common knowledge that castor oil seed and cotton are confirmed enemies of each other and the farmers spent years getting castor oil seed out of the Malwa region of the State but the PAFC is now recommending sowing of crops in the cotton belt (Fazilka) under a new scheme.

The PAFC has planned to bring a very large area under durum wheat. The study conducted at PAU has revealed that our durum wheat is uncompetitive in the international market as well as in the southern States. USA and Canada, etc. provide huge subsidy to their producers as well as exporters; therefore, we are unable to compete with them. Similarly, the wholesaler in Punjab had to bear a loss of Rs 22 per qtl for sale of durum wheat at Hyderabad. Madhya Pradesh and Rajasthan are two competing states for Punjab durum wheat. Therefore, most of the millers/traders from south India

prefer to buy durum wheat from these two states. For the purchase of wheat there, the transportation cost and market taxes and levies are also low. Therefore, the proposed area under durum wheat may be drastically reduced keeping in view the ground reality.

The following policy measures will bring improvement in the contract system in the State:

(i) This system may be made legal. It should be obligatory on the part of contract farmers and the buying companies to strictly adhere to the contract. Both parties, i.e. farmers and the company, may keep one copy of the agreement. The contract farmer may be blacklisted in case he does not deliver the produce. Similarly, the company may be fined in case of non-acceptance of the produce. The State Government may bring suitable legislative measures in this regard.

(ii) The Punjab Agricultural University and the Department of Agriculture, Punjab may be actively associated with this scheme. Only PAU recommended varieties of various crops may be sown under the contract farming system in the State.

(iii) The seed and other farm inputs supplied to the farmers by the companies should be of good quality and tested as per Punjab soil and other climatic conditions.

(iv) The present contract farming is pro-large farmers. The small and marginal farmers should be covered under this scheme.

(v) The manpower available in the Deptt. Of Agriculture must be used for extension activities of the system instead of on payment by the companies.

(vi) More processing units should be set up in the state so that agro-processing and value addition for perishables is undertaken on a large scale which is the mandate of the Punjab Agro-Industries Corporation.

(vii) To cover the production risk, crops under this system should be covered under crop insurance schemes.

(viii) There should be a dispute settlement mechanism in the contract system.

(ix) The proposed area for durum wheat may be increased to 20 thousand acres in 2003, 40 thousand acres in 2004, 60 thousand acres in 2005, and 80 thousand acres in 2006 and one lakh acres in 2007. The modest increase in area every year will pose minimum problems and the contract system may be smooth; and

(x) Cooperative societies/companies should provide adequate finance and technical know-how to the growers.

The views expressed in the papers are authors' own.

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Feature

Production & Marketing of Milk in Central Uttar Pradesh

Manjushree Banerjee & S.R. Yadav

A study was conducted in a district of Central Uttar Pradesh to find out the different milk marketing systems that exist in that locality and their impact on the producer's income. The study also covered the consumers' problems and their opinion. The author reports the conclusion of the study and suggests a few recommendations pointing towards a strong need for a organized milk marketing system.

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India owns the largest livestock population in the world with 57 per cent of the world's buffalo population. The majority of these animals are reared under suboptimal conditions due to the low economic status of the livestock owners. Yet, India has now become the largest producer of milk. Global milk production in the year 2000 was 576 mt more than that of 1999. This increase was due to the increased milk production of India and USA. Milk production in India during 1950-51 was 17 mt. It went up to 81.4 mt in 2000-01. In spite of the increasing trend in production, per capita availability of milk was 214 gm per day in India, which is lesser than the recommended value of 280 gm per day. India produces nearly 13 per cent of the total milk produced in the world. But only 20 per cent of the milk manages to travel long distances to reach the ultimate consumer.

Within 20 years there has been an increase of 66 mt in milk production in India by spending a mere Rs. 700 million per annum. Factors such as lowest cost of milk production (21$ per 100 litre) in the world, absence of any subsidy, and increasing production have attracted many multinational companies. With India joining GATT and WTO, the focus now is on taking steps for developing free economy in trade with increasing competition in the global market, the Indian dairy industry needs to improve animal productivity, reduce cost of production of milk, and improve the quality of milk and milk products.

Table 1(a): Distribution of Sample Households Under Different Categories

Category of producers	Rural (Non members)	Rural (members)	Urban producers
Small	5(20)	15(60)	8(32)
Medium	9(36)	7(21)	3(12)
Large	11(44)	3(12)	14(56)
Total	25(100)	25(100)	25(100)

(Figures in parentheses indicate percentage).

Table 1(b): Investment Pattern in Dairy Enterprises in Different Categories of Sample Households

Category of producers / Particulars	Rural (Non members)				Rural (Member)				Urban Producers			
	Small	Medium	Large	Overall	Small	Medium	Large	Overall	Small	Medium	Large	Overall
Total Investment (In Rs per animal unit)	33296	44111	34317	37639	35587	3556	37708	35759	32727	33949	38359	36027
Total Investment (In Rs per household)	50006	84704	169542	115093	43735	81207	174575	69928	35119	85324	328384	205371

Table I(c): Milk Production and Disposal Pattern of Different Categories of Sample Households

Category of Household Particulars	Rural (Non members)				Rural (Member)				Urban Producers			
	Small	Medium	Large	Overall	Small	Medium	Large	Overall	Small	Medium	Large	Overall
Milk produced (In Lit)	3479	8754	19947	12624	4517	9358	20344	7772	1935	7418	45060	26743
Value (in Rs.)	35593	89837	207496	130758	48355	100476	221505	83727	27699	102219	606898	360993
Home consumption (In Lit)	631	1201	1352	1154	1154	1001	1243	649	471	982	1255	972
Value (In Rs.)	6305	12013	13523	11535	12354	10505	13049	6812	5698	13752	1758	13605
Marketable surplus (in Lit)	2848	7552	18594	11470	3363	8357	19101	7123	1464	6436	43804	25771
Value (in Rs.)	28483	75524	185943	114700	36001	87749	200563	74792	20493	90098	613263	360796

In terms of marketing, out of the total milk produced in India, only 10 per cent is marketed by the organized sector, whereas a whopping 55 per cent is handled by traditional dudhias or halwais. The rest is retained by milk producing households for home consumption and local sales. Around 55 per cent is converted into traditional products such as curds, khoya, etc. Liquid milk is consumed to the extent of 40-45 per cent, while western products such as cheese, milk powder etc. account for 5 per cent of the milk produced.

Uttar Pradesh is predominantly an agricultural state with excellent potential for milk production. Steps taken up by the government to increase milk production have also touched Central Uttar Pradesh. There is a strong network of dairying in the region, from production to consumption, due to a good proportion of cattle, high production and significant importance of milk in the local diet. In the recent past, many private milk companies, at the regional level, have entered the market (such as Gyan) offering stiff competition to cooperative dairying. This has certainly strengthened milk production and marketing in the district and has helped the industry to move forward. Yet, it seems that there is a lack of an efficient marketing system. Most of the milk is channelled through vendors. To boost the production at the village level, and to avoid wastage of this perishable item, there is a need for strong and efficient marketing of milk in the region. The paper analyses the above problem with the following objectives:

1. To identify the different systems of marketing of milk in Central Uttar Pradesh.
2. To study the impact of different systems of milk marketing on the producer's income.
3. To work our marketing costs and producer's share under different systems of marketing.
4. To study the problems of marketing of milk under different systems.

Methodology

District Kanpur Nagar in Central Uttar Pradesh was

selected purposely for the investigation due to the high concentration of milkmen. Milk producers were categorized into two viz. urban and rural. A stratified sampling technique was followed for the selection of respondents. Out of all the blocks of districts, Bidhnu block was selected as a random choice. Five villages were selected from the said block. Out of the five villages, four had primary milk cooperative societies. For the selection of respondents, a list of milk producers was prepared from the selected villages. The milk producers were categorized into members of the milk cooperative society and non members. Twenty five milk producers from each category were selected. Further, the producers were categorized into subgroups viz. small (owning upto two milch animals), medium (owning three to five milch animals) and large (owning more than five milch animals) producers. Among the urban producers, five areas of Kanpur Nagar were selected depending on the concentration of milk producers. Twenty five producers were selected randomly from the prepared list and were categorized into small, medium and large. Both primary and secondary data were used for the study. Primary data was collected through personal interviews and pretested schedules.

Socio Economic Structure of Sample Households

This section describes the family composition of the milk producers, their educational status, investment pattern in dairy enterprise, and size and composition of dairy herd. Table 1(a) represents the distribution of sample households on different categories of rural and urban areas. The table clearly shows that large producers prefer to dispose of the surplus milk through their own channels, while small producers find it profitable to sell the surplus milk to the cooperative society.

Family size showed an increasing trend from small to large producers. Data clearly reveals that the proportion of graduates was significantly higher among large producers of the member category than in the non-member category. However, overall proportion of educated members was higher among urban producers than rural producers.

Size of the herd possessed by the milk producers became one of the main criteria for distribution of samples. Processed data clearly showed dominance of cross bred cows among urban producers, whereas the proportion of she buffaloes was significantly high among rural producers when compared to that of their urban counter parts. The average investment in dairy enterprise along with investment per standard animal unit was worked out considering minute details. Table 1(b) presents the investment pattern in dairy enterprise per household and per standard animal unit. The table explains higher overall investment per household among non members (Rs. 115093.05) than members (Rs. 69927.83). This is due to more number of large producers in the non-member category. Total investment in dairy among urban producers was higher than their rural counterparts. This is the out come of high land value in urban areas.

Total investment in dairy among urban producers was higher than their rural counterparts.

Since investments depend upon the number of animals of different types maintained in the household, a comparison of the investment made per animal is possible only in terms of standard animal unit. The overall investment per animal unit among urban producers was higher than rural producers. Again, the same was more among large producers than small producers in all the categories. This is because large producers possess more equipment such as cutter engine, power cutter, vehicle for dairy purpose, etc. whereas small producers rent these equipment.

Table 1(c) presents the amount of milk produced, the amount consumed at home and marketable surplus of different categories of sample households under the heading Milk Utilization and Disposal Pattern. A look at the table shows that production and disposal of milk through cooperative societies is beneficial, especially for small producers. Urban producers are in a better position than rural producers in terms of production and marketable surplus.

Findings

The findings of this study are discussed under three sub headings – (a) Economics of milk production, (b) Marketing of liquid milk, and (c) Problems and constraints of producers, intermediateries and consumers, including consumers' opinion.

(a) Economics of milk production

Economics of milk production forms the base for the analysis of estimation of resource use efficiency and profitability of the enterprise. Table 2 shows total maintenance cost, net returns and cost of production per litre of milk for the categories – desi cow, cross breed

Table 2: Summary of Costs and Returns of Milk Production (In Rs.)

S.No.	Category of producers	Total maintenance cost	Gross return	Net return	Farm labour income	Farm business income	Cost of production/ Litre of milk	Input output ratio
1.	Rural non members	106685.40	125173.33	18487.76	28908.37	40656.32	6.67	1:1.17
(i)	Deshi cow (animal unit/annum)	9022.35	9677.24	654.88	1504.33	2487.44	6.86	1:1.07
(ii)	Cross breed cow (animal unit/annum)	20562.43	25846.54	5284.11	7209.11	8818.59	6.32	1:1.26
(iii)	She buffalo (animal unit/annum)	19588.15	22977.12	3388.96	5313.96	7526.75	6.85	1:1.17
2.	Rural (Members) (household/annum)	75042.24	90074.52	4917.37	23087.72	31991.09	6.72	1:1.20
(i)	deshi cow (animal unit/annum)	9089.11	10066.00	976.88	1827.21	3498.33	6.86	1:1.11
(ii)	Cross breed cow (animal unit/annum)	20579.92	27119.60	6539.63	8664.63	10335.75	6.31	1:1.32
(iii)	She buffalo (animal unit/annum)	19267.87	23088.88	4006.58	5931.58	8144.37	7.01	1:1.19
3	Urban producers (household/annum)	240344.07	339016.90	118681.65	142790.19	162032.96	8.32	1:1.41
(i)	Deshi cow (animal unit/annum)	11671.66	13046.84	1375.17	3666.83	4620.31	9.65	1:1.12
(ii)	Cross breed cow (animal unit/annum)	24193.09	37104.72	12912.72	15204.62	16974.43	7.31	1:1.53
(iii)	She buffalo (animal unit/annum)	22894.43	33148.80	10254.36	12546.02	14782.05	8.18	1:1.43

cow and she buffalo. The table clearly points the profitability of the cross breed cow over the she buffalo and the deshi cow on all the categories. Analysis for cost and return can be done by two sides viz., per animal and per household. the table also contains the summary of cost and return of milk production on per animal basis. The table clearly shows that net return, farm labour income, farm business income and input-output ratio are highest for the cross bred cow followed by the she buffalo among all the three categories of producers. It may be concluded that keeping a cross bred cow for milch purpose is the most profitable followed by the she buffalo. A summary of cost and return of milk production per household basis is presented in the same table. The table reflects that over all net returns, farm labour income and farm business income are highest for urban producers, followed by rural non-members. Urban producers, taking the benefit of their place, are enjoying more profit than rural producers. Due to higher proportion of small producers in member category, farm business income from dairy enterprise is lower among member category than non members. In spite of the above, input output ratio for member category (1:1.20) is higher than non member category (1:1.17). This reveals that disposal of surplus milk through cooperative societies is beneficial for small producers.

(b) Marketing of liquid milk

Liquid milk is not only highly perishable but also difficult to carry across long distances. Therefore, milk is normally marketed in the local market. A certain amount of surpius milk goes through processing and is bought by the consumers in the form of pasteurized milk. Milk processing activity enables the consumer to get liquid milk at a location that is distant from the producer. In the rural areas of Kanpur Nagar, almost all households have a dairy enterprise. Due to large amount of surplus milk and good communication facilities, everyday, a huge amount of milk is distributed in the urban areas through different channels. Mainly five different channels were identified for the distribution of liquid milk in the study area. These are:

Channel I: Producer - Consumer.

Channel II: Producer - Milk Vendor-Consumer.

Channel III: Producer - Milk Vendor-Halwai-Consumer.

Channel IV: Producer - Primary milk producers' co-operative society-Kanpur milk producers' cooperative union-Agent-Consumer.

Channel V: Producer-Collection-Private Dairy Company-Agent-Consumer.

Data revealed that almost 100 per cent of the marketable surplus among small producers of non-member category is sold through village vendors, and through the cooperative society members. For small producers carrying the milk to distant places is not profitable, and so disposing of the milk at a nearby cooperative society is the most reasonable solution. Around 42 per cent of the marketable surplus among medium producers of non-member category is sold through village vendors and 25 per cent is directly sold to urban consumers. 65 per cent of marketable surplus from medium producers of member category is dis-

Table 3: Price spread per litre of milk while marketing through different channels

S. No.	Particulars	Channel-I				Channel-II				Channel-III		Channel-IV		Channel-V	
		Cow milk		Buff. milk		Cow milk		Buff. milk		Buff. milk		6% fat 9% SNF		6% FAT 9% SNF	
		Rs.	%	Rs.	%	Rs.	%	Rs.	%	Rs.	%	Rs.	%	Rs.	%
1.	Producer's share	11.60	89.23	13.60	90.66	9.38	72.15	10.38	69.20	10.38	64.87	10.15	63.43	10.10	63.12
2.	Total marketing cost	1.40	10.76	1.40	9.33	1.70	13.07	1.70	11.33	2.25	14.06	4.54	28.37	4.05	25.31
3.	Marketing margin of middleman/ coop/dairy company	–	–	–	–	2.10	16.15	3.10	20.66	3.65	22.81	1.31	8.18	1.85	11.56
4.	Consumer's price	13.00	100.0	15.00	100.00	13.00	100.00	15.00	100.0	16.00	100	16.00	100	16.00	100

posed through cooperative societies, while 22 per cent is sold to village vendors. Large producers of non-member category sell 39 per cent of milk to halwai's and 38 per cent to urban consumers directly. Quantity disposed through private dairy collection centres is 3.2 per cent. Large producers among the member category dispose of 49 per cent of milk through cooperative societies and 18 per cent directly to urban consumers.

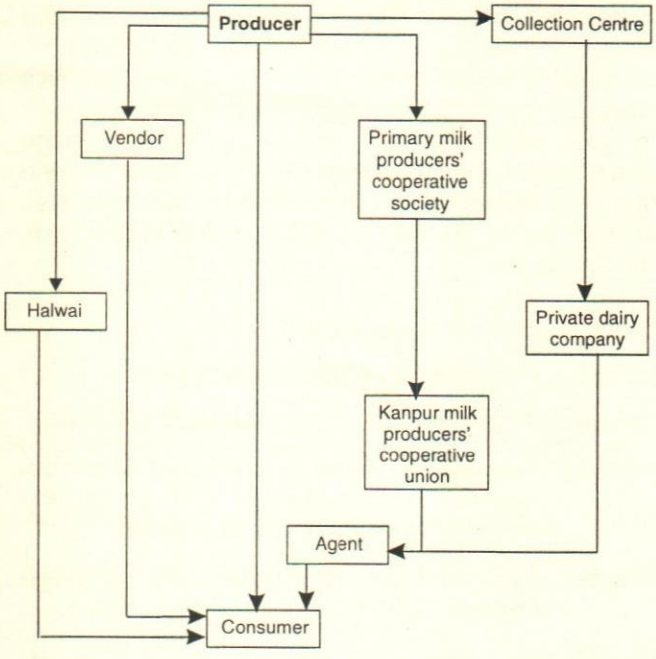

Fig. 1. Different channels for marketing of liquid milk in Central Uttar Pradesh (district Kanpur Nagar)

Marketing Cost and Margin: Marketing cost incurred per litre of milk for all the channels is presented in Table 3. For channel I marketing, the cost was worked, out separately for cow and buffalo but it came out to be rupees 1.40 per litre for both. Halwai prefers buffalo milk. That is why the marketing cost for buffalo milk was worked out only for channel III, which came to Rs. 2.25/- per litre. This is more than channel II (Rs. 1.70 per litre) due to more number of intermediaries. Milk reaches consumers through cooperative societies and private dairy companies in channel IV and channel V respectively. Marketing cost is worked out for milk with 6 per cent fat and 9 per cent SNF (solid not fat). Marketing cost for channels IV and V came out to be Rs. 4.45 and 4.05 per litre of milk, respectively.

Price spread: Price spread for all the channels is presented in Table 3. Percentage share of total marketing cost for consumer's rupee was highest for channel IV (28.37%) followed by channel V (21.31%). Thus from the table we can say that percentage share of total marketing cost for consumer's rupee increases with the length of the marketing channel. The marketing margin of the middleman is more in channel III (22.81%) than channel II (20.66% for buffalo milk and 16.15% for cow milk). Percentage share for marketing margin of channel V is 11.56 per cent and 8.18 per cent for channel IV. The lowest marketing margin is seen in channel IV, the reason may lie in the principles of the cooperative society. From the table we can see that the producer's share in consumer rupee is highest in channel I (89.23% for cow milk and 90.66% for buffalo milk). The producer's share in consumer rupee is lowest in channel V (63.12%) followed by channel IV (63.43%). From the above findings, it may be concluded that producer's share in consumer rupee decreases with the increase in the length of the marketing channel, mainly due to transportation costs and margin of profit charged by middlemen.

(c) Problems and constraints of producers, intermediateries and consumers including consumers' opinion.

Problems faced by producers, intermediaries and consumers in the study area were quantified. Table 4(a) shows the quantification of the problems faced by producers based on the findings of the research. There are mainly three types of intermediaries viz. Vendors,

Cooperative society & Private milk companies. All the three cited a few common problems such as inability to meet consumer demand and producer payments during lean season, transportation and storage along with leakage problems. Cooperative society pointed out that number of farmer members is decreasing day by day. This may be the result of popularity gain in the vendor business. Private Dairy companies complain about inadequacy of working capital.

Table 4(a): Quantification of problems faced by producers

Category producers Problems	Rural (Non member) (%)	Rural (Member) (%)	Urban Producers (%)
Problem in persuading vendors for disposal of milk.	30.25	–	–
Fluctuation in price of milk depending on season.	20.32	15.50	–
Medical and insemination facility for milch animal being costly and not available in time.	90.02	92.95	80.45
Problem of milk quality not sold.	40.25	–	20.93
Problem of transportation.	60.45	98.02	90.45
Delay in payments by customers/cooperatives/ vendors.	23.00	90.34	15.50
Malpractices followed in testing the quality of milk by cooperatives and problem of favouritism.	–	50.32	–
Problem of high labour cost feed and fodder cost.	10.35	10.50	90.35
Space problem.	–	–	60.35

Table 4(b): Quantification of problems faced by consumers

Source Problems	Vendor	Private dairy	Packet milk	Own milch animal
Problem of adulteration	76.66	49.39	–	–
Conditions	40.39	69,35	5.02	–
Irregularity in supply	25.34	24.39	–	–
Malpractices regarding quantity and quality	10.32	14.35	–	–
Time consuming	20.34	80.45	30.34	90.94
Problem of high cost	50.02	57.32	45.32	60.03

Consumer problems have also been quantified in this study based on the survey. Table 4(b) shows the quantification of the problems faced by consumers.

Consumers' opinion: Through a survey conducted in the urban part of the study area the preferred channel of the consumer for milk procurement was identified. 100 households were selected randomly. It was found that 39.02 per cent of the households procures milk from the village vendor and 28.04 per cent from the private dairy. About 25.60 per cent of households depend solely on packet milk, while 7.31 per cent of households maintain their own milch animal. Whatever channel the consumer prefers, he/she has to depend partially on packet milk.

Conclusion and Policy Options

On the basis of the findings, the following conclusions may be drawn:

(1) Mostly, small producers are members of the cooperative society and most of the large and medium producers dispose of their surplus milk through direct sale.

(2) Cost of production per litre of milk decreases with the increase in the size of enterprise.

(3) Keeping cross breeds is more profitable than keeping she buffaloes.

(4) Dairy enterprise is more profitable to urban than rural producers.

(5) Considering per litre price of milk, marketing through cooperative societies is more profitable for producers than other channels.

(6) With the increase in the length of the marketing channel, the producer's share in consumer rupee goes on decreasing.

(7) Problem of transportation, delay in payments and high maintenance cost were found to be prominent problems among different categories of producers. Similarly, adulteration, unhygienic conditions and interruption in supply were problems.

(8) Though each and every household in the urban area depends on packet milk, maximum number of consumers procure milk through vendors.

In spite of most cooperative members being small producers, input-output ratio was highest for cooperative members. To increase the profitability of the enterprise for producers, milk cooperatives should be encouraged to extend their roots to wider areas and reach maximum number of farmers. Cost of production

decreases with the size of the enterprise. Hence, the procedures for credit procurement should be made easy so that producers can avail the facility and increase the herd size. Findings point out that milk production is sufficiently high in the study area but what is lacking is an organized marketing system. Only 15 per cent of the marketable surplus goes through the organized channel and processing units. Private dairy plants should also be encouraged. Both cooperative and private dairy companies can procure maximum amount of marketable surplus, and along with meeting consumer demand for liquid milk, can diversify for production of other milk items like khoa, cheese, butter, dahi, ghee and milk powder. More output through the plants will ensure better profitability of the whole milk marketing system. For all these, farmers should be attracted towards cooperative societies. This can be done by education and training regarding the benefits of cooperative societies in villages. Since consumers procuring milk from vendors face problems of adulteration, the problem can be overcome by marketing through organized channels, which can ensure quality control system in their dairy plants.

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Don't forget that it (your product or service) is not differentiated until the customer understands the difference.

– Tom Peters

Feature

Trends in Pulse Production in Maharashtra

Shrikant S. Kalamkar

An attempt has been made in this paper to study the past performance and the constraints in raising pulse production in Maharashtra. A crop-wise study was done and the analysis should enable the planners and policy makers to accelerate the growth process.

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The introduction of new technology during the mid-sixties has changed the shape of Indian agriculture. The large increase in the production of foodgrains after the mid-sixties, commonly describes as *Green Revolution*, has changed the situation from chronic food shortage to self-sufficiency. The production of foodgrains has increased from just 75 million tonnes in 1966-67 to about 212.0 million tonnes in 2001-2002 (GOI, 2003). However, the impact of green revolution was localised to rice and wheat crop only (Kalamkar, et al, 2002), pulses remained completely untouched by the new agricultural technology. The production and productivity of pulses was almost stagnant over the last four decades. This led to continuous decline in per capita availability and a wide gap between supply and demand. Despite many promotional schemes for increasing pulses production during the different plan periods, the production of the 1990s was almost the same as in the early 1960s (Table 1).

Table 1: Decadal trends in area, production, yield of pulses

Year	Area (million ha)	Production (million tonnes)	Yield (kg/ha)
1950s	22.0 (15.3)	10.5	477
1960s	23.1 (14.6)	11.1	481
1970s	22.8 (13.5)	11.0	482
1980s	23.1 (13.1)	12.2	527
1990s	22.9 (12.1)	13.7	601
1999-2000	22.28 (11.5)	13.6	608

Note: Figures in parantheses indicate percentage to gross cropped area

Source: GOI (1999 and 2002)

Importance of Pulses

Pulses occupy an important position in the agrarian economy of our country as the primary and cheapest

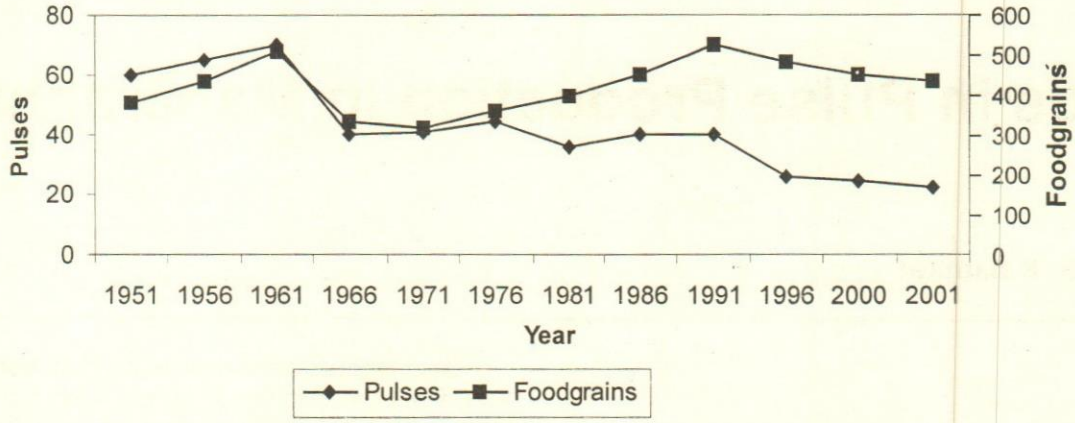

Fig. 1. Net availability of pulses and foodgrains in India (grams/capita/day)

sources of vegetable protein for the poor and the vegetarian who constitute the majority of the population. Protein content of different pulses varies from 20 to 40 per cent which is two to three times more than the cereal grains (wheat and rice). Pulses are equally important for maintaining the soil health of different cropping systems. By virtue of being a restorer of soil fertility, pulses have a unique position in the cropping system and dry land/rainfed agriculture. From the agronomic points of view, pulse crops increase soil fertility through the nitrogen-fixing bacteria present in the root nodules and thus, minimize dependency on chemical fertilizers, which lead to environment pollution. According to one estimate, pulses leave between 30 to 40 kg of nitrogen per hectare of soil. Due to the tap root system, these crops open up the soil by which soil aeration improves. The heavy leaf drop increases the organic matter in the soil. Pulses also trap the moisture from the lower strata of the soil, therefore, they are considerably moisture stress (drought) tolerant and fits well in rainfed environment. Pulse crops also increase the sources of income of the farmers by way of inter- cropping, frequency, and crop intensity.

Despite their importance, the per capita availability of pulses in India has been continuously decreasing. As a result of the surging population and stagnating pulse production, per capita availability of pulses has steadily declined to almost half from about 60.7 grams/day in 1950-51 to 26.4 grams/day in 2001 (see, Table 2) as against the recommended (43 gm/day) of the Indian Council of Medical Research. The increasing shortage of pulses, resulted in more and more imports. The average import of pulses was 870 thousand tonnes per annum during the five years ending 2001, with an extreme of 2177 thousand tonnes in 2001-02. In value terms, it was approximately US $270 million for the former and a peak of US $886 million in 2001-02 (Joshi and Saxena, 2002). Despite an open trade regime and increasing domestic prices for pulses, imports were inadequate to fill the supply demand gap. Production must grow by about 500,000 metric tonnes per year to keep up with the growth in population. To meet the growing needs of the country, pulse production programmes were initiated with different development strategies during plan periods.

Table 2: Net Availability of Pulses and Foodgrains in India from 1951 to 2001

Year	Pulses		Foodgrains	
	kg per year	Grams/ capita/day	kg per year	Grams/ capita/day
1951	22.1	60.7	144.1	394.9
1956	25.7	70.3	157.6	430.7
1961	25.2	69	171.1	468.7
1966	17.6	48.2	149	408.1
1971	18.7	51.2	171.1	468.8
1976	18.5	50.5	155.3	424.3
1981	13.7	37.5	166	454.8
1986	16	43.8	174.3	477.5
1991	15.2	41.6	186.2	510.1
1996	12	32.8	173.8	476.2
2000	11.7	32	167.2	458.0
2001	9.6	26.4	152.2	417.0

Source: GOI (2002).

Once the net exporter, India is presently one of the largest importer of pulses because our domestic production is chronically short of the demand.

Table 3: Production of cereals, pulses and total foodgrains in Maharashtra and India

(in million tonnes)

Year	Maharashtra					India				
	Cereals	Pulses Production	Food-grains Production	Cereals Pulses Ration	Pulses as % of Foodgrains	Cereals	Pulses Production	Food-grains Production	Cereals Pulses Ration	Pulses as % of Food-grains
1960-61	6.75	0.99	7.74	6.82	12.78	69.32	12.7	82.02	5.46	15.48
1965-66	4.03	0.66	4.69	6.07	14.15	62.41	9.94	72.35	6.28	13.74
1970-71	4.74	0.68	5.41	7.00	12.50	96.60	11.82	108.42	8.17	10.90
1975-76	7.87	1.17	9.04	6.74	12.93	107.99	13.04	121.03	8.28	10.77
1980-81	8.65	0.83	9.47	10.48	8.71	118.96	10.63	129.59	11.19	8.20
1985-86	7.55	1.16	8.71	6.52	13.29	137.08	13.26	150.44	10.26	8.88
1990-91	10.74	1.44	12.18	7.45	11.83	162.13	14.26	176.39	11.37	8.08
1995-96	10.01	1.64	11.65	6.11	14.07	168.11	12.31	180.42	13.66	6.82
1999-00	8.50	1.64	10.13	5.19	16.15	188.01	13.55	201.56	13.88	6.72

Sources: GOI (1999) and GOM (various issues)

The technical change in pulse crops is slow compared to superior cereals and other cash crops. Pulses have to compete with the superior cereals and cash crops for resources, research and infrastructure. Evidence indicates that displacement of acreage of these crops has been marked in areas which have witnessed the introduction of high yielding varieties (HYV's), seeds, use of chemical fertilizers and better farming practices (Singh, 1979). Inadequate production technology, price variability, production risk and low level of irrigation are the important influencing factors responsible for decline in acreage and stagnation in the productivity of pulse crops. Though the country had to import pulses due to huge supply demand gap, there has been no breakthroughs in the production of pulses (Ramasamy and Selvaraj, 2002). Non availability of good high-yielding varieties, as in the case of paddy and wheat, was one of the main reasons for the slow growth in pulse production. According to the National Commission on Agriculture (1976), the country has the potential to meet the anticipated demand of pulses through domestic production. The situation of stagnation has arisen because not enough and timely attention has been given to the technological, institutional and pricing frarne work in which pulses are produced and marketed (Vashisht, et al., 1996).

Data and Methodology

For this study, both the micro and macro level data were collected and analysed. Macro level data were collected from secondary sources like Districtwise Agricultural Information of Maharashtra State, Bulletin on Food Statistics, Agricultural Statistics at a Glance and Indian Meteorological Department, Pune. For micro level study, primary data were collected through the farm household well-prescribed questionnaire. The survey was conducted in Nagpur and Yavatmal districts for Pigeonpea/Tur (Cajamus cajan); Jalgaon and Nasik districts for Chickpea/Gram (Cicer aritinum) crop. From the four selected districts, a total sample of 216 farmers were selected through the stratified random sampling method based on the size of operational holdings of farmers. The reference year for the study was 2000-2001. The compound growth rates were calculated by using the exponential function.

Historical changes in Pulses Production

Probably no other country produces and consumes as varied an array of pulses as India. India is the largest grower and producer of pulses in the world, as it ranks first in both production and area under pulses. Despite being the largest producer, the pulse productivity is one of the lowest in the world. In 2001, the area and production of pulses in India was 22.28 million hectares ad 13.55 million tonnes, respectively. It formed 26.46 per cent of world production. India's yield (595 kg/ha) lagged far behind that of the world average (795 kg/ha). Once the net exporter, India is presently one of the largest importers of pulses because our domestic production is chronically short of the demand. The crisis of pulses is due to growth in population and introduction of protein based food industries. To bridge the gap between demand and supply of pulses, India needs a manifold increase in pulse production.

The per cent contribution of pulses in total

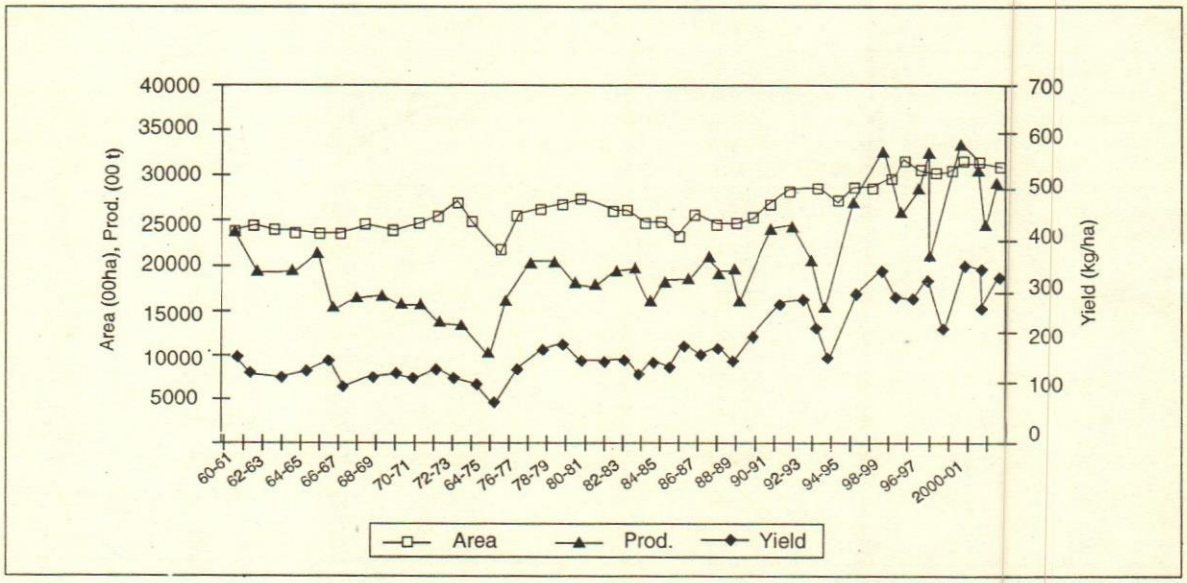

Fig. 2. Trends in production and productivity of total pulses in Maharashtra

foodgrains production in India has declined during the last three decades by 8.76 per cent in 2000 over 1960 (Table 3). The ratio of cereals to pulses which was just about 5:1 in the early 60s has increased to almost 14:1 in the late 90s. Share of pulses in foodgrains production, which was over 15 per cent in the early 60s decreased to just about 7 per cent in the late 90s. The area under pulses increased from 19.09 million hectares in 1950-51 to 22.28 million hectares in 1999-2000. In relative terms, area under pulses has been hovering around 18.1 per cent of the total area under foodgrains, however, accounting for only 6.72 per cent of total production. As cereals pulses ratio goes on increasing over a period of time, percent contribution of pulses has decreased from 16.55 per cent to 6.72 per cent. Attention has already been given to various aspects of production and related issues of the rice and wheat crop. As a result of this, crop area and production has increased by more than double in the last four decades, whereas area under pulses has declined from 22.54 million hectares in 1970-71 to 20.0 million hectares in 2000-2001. There has only been a marginal increase in pulse production, which is not sufficient to meet the growing demand. That resulted in a decline in per capita availability of pulses and increase the demand supply gap. As the percentage of gross irrigated area to gross cropped area in the country increased over a period of time, the pulse crops have not duly shared the increased area under irrigation. However, the area of pulses has not gone up because they are cultivated in areas totally devoid of irrigation facilities. Only 9 per cent area under gram is irrigated whereas, 80 per cent under wheat and more than 90 per cent under paddy have assured water availability. So far as the pulses production scenario in the different states of the country is concerned, Maharashtra is the largest producer of pulses.

Pulse development in Maharashtra

Maharashtra State contributes 17.72 per cent of the area under pulses in the country, accounting for 15.37 per cent of pulse production in 2001. Maharashtra ranks first in area and production of tur accounting for 29.89 and 29.20 per cent, respectively. However, in the case of gram, the state ranks third in area (13.91 per cent) and fourth in production (9.94 per cent). Maharashtra, inspite of being the largest producer of tur and gram, attained a low level of yields (602 and 519 kg/ha, respectively). Among the various pulses grown in the state, kharif pulses occupy a major share both in terms of area and production and are also grown as mixed as well as pure crops. Tur (C. cajan), Mung (V. radiata) and Urad (V. mungo) are among the major kharif pulses of Maharashtra. In the rabi season, Gram (C. arietinum) forms the major rabi pulse. Tur and gram are the two important pulse crops grown in most of the districts of the state. Due to different agro-climatic conditions in the state, the changes in area, production and productivity are not uniform in all the districts in Maharashtra. The per cent contribution of pulses in total foodgrains production in Maharashtra has increased during the last three decades by 4.65 per cent in 2000 over 1960 (Table 3). Cereal pulses ratio decreased from 7:1 to 5:1, however, percentage contribution of pulses in foodgrains increased from 12.78 per cent in 1960-61 to 16.15 per cent in 1999-2000. The area under pulses in the 1960s was 24.54 lakh hectares. Thereafter, it increased to 26.93 in the 1970s; 33.78 lakh hectares in the 1990s and

Table 4: Decadal trends in area, productivity, yield of pulses in Maharashtra

District	Year	Tur			Gram			Total Pulses		
		A	P	Y	A	P	Y	A	P	Y
Nasik	1960s	64.5	43.7	678	203.5	69	339	963.3	358.9	373
	1970s	56	50.1	895	206.2	78.2	379	1087.3	439.6	404
	1980s	55.7	42	754	323.6	139.9	432	1065.7	433	406
	1990s	84.9	54.1	637	516.3	292.6	567	1130	581.7	515
	2000-01	86	30	349	242	109	450	901	367	407
Jalgaon	1960s	113.1	72.2	638	39	14.5	372	1961.7	696	355
	1970s	103.2	69.2	671	72	36.1	501	2101.6	811.5	386
	1980s	145	102.3	706	197.6	112	567	1856.8	864	465
	1990s	241.2	168	697	508.6	371.6	731	1808.5	1113.2	616
	2000-01	257	85	331	252	170	675	1569	553	352
Yavatmal	1960s	433	409.3	945	72.9	21.2	291	929.4	501.5	540
	1970s	466.2	375.5	805	74.6	24.6	330	1034.9	495.4	479
	1980s	666.1	568	853	72.2	29.6	410	1270.3	732.8	577
	1990s	1080.8	934.9	865	151.7	77.9	514	1997.1	1391.3	697
	2000-01	1195	1390	1163	368	196	533	2215	1843	832
Nagpur	1960s	376.8	204.1	542	86.7	28.7	331	619.2	274.9	444
	1970s	395.6	189.8	480	119.8	39.1	326	677.9	257.7	380
	1980s	446.2	241	540	192.4	81.2	422	825.1	382.4	463
	1990s	529.8	293.1	553	311.4	166.3	534	1020.4	522.2	512
	2000-01	487	302	620	267	129	483	887	484	546
Maha State	1960s	5789.9	3311.4	572	3616.4	1144.4	316	24541	8279.5	337
	1970s	6181.8	3222.8	521	3960.2	1308.4	330	26934	9001.1	334
	1980s	7655.8	4771.8	623	5148.4	2137.2	415	29249	12107	414
	1990s	10227	5976.1	584	7122.9	4123.6	579	33783	17447	516
	2000-01	10961	6603	602	6762	3508	519	33572	16369	460

Notes: A = Area in '00' ha. P = Production in '00' tonnes and Y = Productivity in 'Kg/ha'
Sources: GOM (various issues)

Table 5: Trend growth rates of area, production and productivity of pulses in Maharashtra (1960-61 to 2001-02)

(Percent per annum)

Period	Tur			Gram			Total Pulses		
	A	P	Y	A	P	Y	A	P	Y
1960-61 to 1969-70	1.67[a]	–3.65[b]	–5.32[a]	–1.88[b]	–4.16[b]	–2.28[c]	1.51[a]	–1.63	–3.14[a]
1970-71 to 1979-80	2.50[b]	6.36[b]	3.86[b]	3.96[c]	7.47[c]	3.51	2.40[b]	7.91[b]	5.51[b]
1980-81 to 1989-90	3.58[a]	6.07[a]	2.48	4.56[a]	8.72[b]	4.16	2.36[a]	6.72[a]	4.36[a]
1990-91 to 2001-02	0.43[b]	5.04[b]	4.61[c]	3.90[b]	4.62[c]	0.72	0.87[b]	3.25	2.37
1966-67 to 2001-02	2.13[a]	2.98[a]	0.85[b]	2.80[a]	5.26[a]	2.46[a]	1.11[a]	3.17[a]	2.07[a]
1960-61 to 2001-02	1.92[a]	2.25[a]	0.33[b]	2.29[a]	4.23[a]	1.94[a]	1.09[a]	2.56[a]	1.48[a]

Notes: a, b, c are significant at 1, 5 and 10 percent level, respectively. APY as per above table.
Source: GOM (various issues)

finally it reached 35.57 lakh hectares in 2000-01. The production of pulses in Maharashtra ranged between 12 to 18 lakh tonnes. It was 8.29 lakh tonnes in the 1960s, increased to 17.44 lakh tonnes in the 1990s and then decreased to 16.36 lakh tonnes in 2000-01. Thus, area, production and productivity of pulses in Maharashtra increased by near about 38, 111 and 53 per cent in the 1990s over the base period of the 1960s. Inter crop comparison revealed that area under tur and gram crop increased by 77 and 97 per cent whereas, production increased by 260 and 80 per cent in the 1990s over the 1960s, respectively. The productivity of gram increased by 83 per cent whereas tur productivity was almost stagnant and recorded only 5 per cent increase in the above mentioned period (see Table 4).

Tur and gram are the two important pulse crops grown in most of the districts of the state.

The area, production and productivity of pulses in Maharashtra showed a positive trend which is evident from Table 5. Among the pulses, gram has a better growth rate than tur. The increase in production of tur was primarily attributed to an increase in acreage while as regards gram, it was due to an increase in both yield and area. The growth in area, production and productivity of pulse crop was significant from 1970-71 to 1989-90. During the last forty years, the productivity of tur increased, but at a very slow rate (0.33 per cent) as compared to gram (1.94 per cent). During the early sixties, there was a declining trend in yield. Compared with cereal crops like wheat and rice, it was very low.

Demand and Supply Projections

Pulses are the cheapest source of proteins as compared to others. It is estimated that the population of the country would be touching nearly 1350 million by 2020 AD and our minimum pulses requirement would be around 30.8 million tonnes. On the basis of food characteristic demand system the demand projections for pulses for the year 2005, 2010 and 2015 are 20.0, 23.3 and 27.0 million tonnes, respectively. The main challenge in the future scenario will evolve around attaining self sufficiency in pulse production to meet the increasing demand for protein and ensuring environmental security by way of checking the degradation of the soil due to intensive cultivation of high (natural resources) demanding crops (Chaturvedi and Ali, 2002). In case of Maharashtra, it is estimated that the population of the state would be around 2021 lakh in 2031-32 and our pulse requirement would be touching 59 lakh metric tonnes. The demand projections for pulses in the state for the year 2007, 2012, 2017, 2022 and 2027 are 33, 37, 42, 47 and 53 lakh metric tonnes, respectively (MWIC, 1999). According to a preliminary forecast, the pulse production in Maharashtra during 2002-03 is expected to be 16.62 lakh tonnes (less than 11.6 per cent of the previous year). This means that we have to increase our pulses production by 3.5 times in the coming thirty years (every year by 1.4 lakh tonnes) to fulfill demand.

Growth in Pulses Production in Selected Districts

The area, production and yield of pulse crops in the selected districts increased over a period of time. Nasik and Jalgaon are the major gram growing districts; Nagpur and Yavatmal are the major tur growing districts in the state. In case of gram, Jalgaon district recorded tremendous increase in area and production, 1204 and 2463 per cent in the 1990s over the 1960s, respectively. However, there was not much improvement in case of tur. Yavatmal district recorded an increase of 150 and 128 per cent in area and production of tur in the 1990s over 1960s, respectively. It is very surprising that productivity of tur was almost the same whereas gram productivity increased by more than 60 per cent during the said period. The tahsilwise production and productivity of selected farmers under tur and gram crop is presented in Table 6. It could be seen from the

Table 6: Production and productivity of tur and gram under selected farmers.

District	Tahsil	Total holdings (ha.)	Area under crop (ha)	Production (qtl.)	Productivity (ka/ha)
Nagpur	Narkhed	76.0	5.6	44.2	795
	Saoner	71.4	11.9	97.2	817
	Higna	67.8	5.8	47.7	820
		215.2	23.3	189.1	812
Yavatmal	Yavatmal	74.8	10.0	80.5	805
	Wani	77.5	7.8	85.8	1100
	Pusad	79.4	9.3	94.4	1015
		231.7	27.1	260.7	962
Jalgaon	Chopda	86.6	11.2	101.2	904
	Jalgaon	92.8	20.1	194.1	966
	Yerendol	74.2	11.2	100.8	900
		253.6	42.5	396.1	932
Nasik	Nifad	62.6	13.4	82.7	617
	Dindori	89.8	55.2	306.4	555
	Sinner	62.8	9.4	66.5	707
		215.2	78.0	455.6	584

table that in Nagpur and Yavatmal district, tur crop is cultivated to about more than 10 per cent area of the holding. The productivity for tur is ranging from 795 to 1110 kg/ha. The highest productivity was observed in Wani tahsil and the lowest in Narkhed tahsil. In Jalgaon district, gram crop was cultivated in more than 16 per cent of the area of the holdings whereas, it was more than 37 per cent in Nasik district. The productivity for gram is ranging from 555 to 966 kg/ha.

Rainfall

Maharashtra with its geographical area of 30.76 mha receives 1464.0 mm mean annual rainfall as against 1094.4 mm mean annual rainfall in India. In three consecutive years (1999, 2000, and 2001) rainfall was deficient. The trends of the rainfall in different regions of Maharashtra indicate that it declines in the monsoon season and increases in the post monsoon season. It can be seen from Table 7a that the productivity of pulses increased with increase in rainfall (GOM, 2002). The rainfall data of selected districts is reported in Table 7b. It can be seen from the table that the entire district received good rainfall during the last ten years. The highest rainfall was recorded in Yavatmal district (957.0 mm), followed by Nagpur, Jalgaon and Nasik. Pusad tahsil recorded highest rainfall among all tahsils whereas Sinner tahsil had lowest. The average rainfall ranges from 620.9 to 957.0 mm.

Table 7a: Rainfall and Productivity of Pulses in Maharashtra

Year	Total Rainfall (mm)	Pulses Productivity (kg/ha)
1991-92	1236.6	418.0
1992-93	1245.5	542.0
1993-94	1445.3	724.0
1994-95	1357.1	550.0
1995-96	1186.5	554.5
1996-97	1269.6	670.5
1997-98	1389.4	380.0
1998-99	1593.4	712.5
1999-00	1316.8	838.5
2000-01	1401.1	561.0

Source: GOM, 2002

Table 7b: Average rainfall in selected districts (1991-2000) in mm)

Particulars	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Nagpur													
Narkhed	8.4	9.3	15.00	2.0	5.0	137.6	32.82	210.7	166.8	74.1	25.60	8.10	695.4
Saoner	9.2	5.9	22.80	6.18	6.2	177.3	302.3	188.3	181.4	47.7	14.1	12.6	974.0
Higna	9.2	14.3	13.1	10.1	4.4	137.8	282.7	223.2	147.8	40.00	17.5	9.2	909.3
Average	8.9	6.8	16.9	6.1	5.2	150.9	186.1	207.4	165.3	54.0	57.2	9.93	859.5
Yavatmal													
Yavatmal	5.5	12.5	5.3	1.3	7.8	168.0	287.3	240.7	143.6	32.6	14.4	8.7	927.7
Wani	0.3	1.0	1.2	0.4	7.5	140.0	294.2	281.2	125.2	77.3	10.7	3.3	942.3
Pusad	0.2	0.0	4.9	4.8	1.3	248.0	255.8	217.7	165.9	84.3	12.2	6.0	1001.1
Average	2.0	4.5	3.8	2.16	5.53	185.3	279.1	246.5	144.9	54.7	12.43	6.0	957.0
Jalgaon													
Chopda	0.0	0.0	2.6	1.7	20.4	122.8	198.5	175.2	145.9	45.2	5.6	14.6	732.5
Jalgaon	0.0	0.0	3.9	4.1	14.8	131.9	238.1	158.3	148.9	24.3	16.3	4.7	745.3
Yerendol	0.0	0.0	3.7	0.4	3.2	142.7	215.5	151.7	110.0	35.0	0.0	0.0	662.2
Average	0.0	0.0	3.4	2.06	12.8	132.4	217.3	161.6	134.9	34.83	10.95	9.65	713.3
Nasik													
Sinner	0.0	0.0	0.0	0.0	0.0	136.9	113.1	82.1	115.5	112.6	6.5	1.3	568.0
Nifad	0.0	0.0	0.0	0.0	0.0	132.0	122.1	123.7	163.7	117.0	16.9	1.8	667.2
Dindori	0.0	0.0	0.0	0.0.	0.0	114.2	190.2	120.7	119.6	76.3	6.3	0.2	627.5
Average	0.0	0.0	0.0	0.0	0.0	127.7	141.8	108.3	132.9	101.9	9.9	1.1	620.9

Source: Indian Meteorology Department, Pune

Table 8: Yield gap of pulse crops (Qt/ha)

Crop	Yield potential	Demonstrated yield	Yield gap I	Yield at farmers field		Yield gap II
Gram	20-22	15-18	4.5	Small Farms	6.41	10.09
(Chickpea)				Medium Farms	6.84	9.66
				Large Farms	7.99	8.51
				Overall	7.07	9.43
Tur	15-17*	12-15	2.0	Small Farms	8.18	11.07
(Pigeon pea)	20-25**	20-22		Medium Farms	9.39	9.86
				Large Farms	9.23	10.02
				Overall	8.93	10.32

Notes: * early and ** late

Sources: Chaturvedi and Ali, 2002; Sekar and Chand, 2002

Possibilities of Area Expansion

Maharastra was the third largest producer of pulses in the country as of 2000-01. The state has immense scope for increasing area under pulses through popularizing short duration varieties of pulses by fitting them into feasible crop patterns. This, however, would be possible only if the existing available improved production technology in full package is extended to the farmers for adoption on a wider scale. At present, pulse crops in Maharashtra do not compete with the main kharif/rabi crops in terms of profitability. It is certain that pulses can not replace jowar, rice and wheat in the commercial agriculture of the state at present. As such, pulses have either to be grown along with them or fitted in the crop system around that time when land is not being used for growing major kharif/rabi crops.

Productivity Gap

The production can be increased either by bringing more area under cultivation or by increasing yield through adoption of improved pulse production technology or by combining both. Maharashtra has made appreciable increase in the productivity of pulses during the last decade. But, it is much lower than the potential yield of 15-20 qts./ha. It can be observed from Table 8 that there existed a sizeable gap in pulses productivity between the potential, demonstration plots and the sample farmers fields. Yield gap I and II corresponds to the difference between potential and demonstrated yield, demonstrated and sample farmers field yield, respectively. It may be hypothesized that yield gap I is caused by environmental difference and yield gap II is caused by biological and socio-economic constraints. Biological constraints refers to uncontrollable factors like rainfall, pest and diseases and inherent soil fertility while socio-economic constraints refer to the socio-economic conditions that prevent farmers from using the recommended technology, which may be lack of credit and other input availability, attitude and knowledge level of farmer, cost and returns (Johansen et. al., 2000; Sekar and Chand, 2002). It is obvious from Table 8 that there exists a distinct pattern of yield gap among pulse crops. Yield gap II is greater than yield gap I in both pulse crops. In case of gram crop, highest magnitude of yield gap was recorded on the medium farms, whereas in case of tur crop, it was on small farms. The lowest magnitude was noticed on large farms for both crops. Hence, efforts are needed to get rid of biological and socio-economic constraints, which cause yield gap II. Appreciable untapped yield gaps suggest clear-cut scope for enhancing the production and productivity are removed. The major efforts should be to increase productivity per unit of area. This involves a package of well-planned production and protective technologies, coupled with protective irrigation.

Economics of Pulse Crop Cultivation

We analysed per hectare gross returns, cost of cultivation i.e. operating cost and net returns for tur in Nagpur and Yavatmal district; gram in Nasik and Jalgaon districts. A comparison of cost and returns per hectare of included pulse crops reveals that tur gives higher gross and net returns per hectare (Table 9). The gross returns from tur were Rs. 12420 per hectare and the net earnings of operating costs were Rs. 4630/- per hectare. It may be noticed that the highest returns were realised on large farms despite the lower operating costs. It may be the large size of farm that reduced operating costs and resulted in high returns. The data on cost and returns of gram indicate that gross and net returns were Rs. 11435/- and Rs. 5738 per hectare, respectively. The highest net returns were Rs. 7,440 obtained by large cultivators and maximum cost was incurred by large

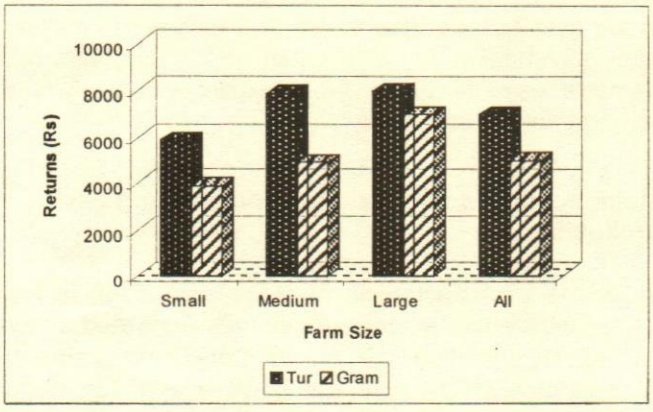

Fig. 3. Per hectare Net returns

farmers as well. In a nutshell, the analysis suggests that net returns of tur in Nagpur and Yavatmal district were significantly higher than that of gram in Nasik and Jalgaon districts.

Table 9: Gross return, return costs and net returns of tur and gram (Rs/ha).

Farm size	Cost of Cultivation	Yield	Gross Return	Net Return
Tur (Pigeonpea)				
Small	4810	818	11050	6241
Medium	4526	939	12933	8407
Large	4556	923	13278	8722
All	4630	893	12420	7790
Gram (Chickpea)				
Small	6118	641	10562	4432
Medium	5389	684	10733	5343
Large	6822	799	13013	7440
All	5693	707	11435	5738

Marketing, Prices and Processing

Efficient marketing and market development are crucial for increasing production of any agricultural commodity. The returns to producers depend on the efficiency of marketing. The pulses are marketed as grains by farmers. The survey results reveal that in case of pulses, growers lack information. Some of the pulse producers sold their market surplus within the village to commission agents. A small portion of cultivators disposed their produce to village shop-keepers/merchants/neighbours. A group of pulse producers sold their produce outside the village in large markets. The price received from traders outside the village was lower and the price received within the village was lowest. The harvest wholesale and retail prices of tur and gram in Maharashtra were subject to wide fluctuations. The uncertainity in prices was quite large as measured by year to year price changes. The percentage change in the harvest prices of tur and gram ranged between 167 per cent and 135 per cent in 2000 over 1990. The wholesale prices were equally volatile but range of fluctuations was found to be comparatively higher. The retail prices of tur and gram also moved along with harvest and wholesale prices during the above mentioned period (see Table 10).

Table 10: Harvest, Wholesale, Retail and Minimum Support Prices of Important Pulses in Maharashtra (Rs/qt.)

Year	Harvest Price	Wholesale Price	Retail price	Minimum Support Prices
Tur				
1990	934	793	1408	480
1993	1158	967	1642	700
1997	2145	1155	2967	900
1998	1994	1483	3725	960
1999	1992	1783	3533	1105
2000	2025	1511	2512	1200
Gram				
1990	560	697	1317	450
1993	721	998	1640	640
1997	1252	1221	2125	740
1998	1132	1189	2483	815
1999	1203	1211	2200	895
2000	1313	1428	2104	1015

Source: GOI (various issues)

The gap between the prices received by the producers and prices paid by the consumers was significantly high, because most of the pulse growers are forced to sell their market surplus at low prices immediately after harvesting. It is either due to their financial commitments or due to the lack of storing and other infrastructure facilities at the village level. The growers of pulses do not assess milling facilities. Therefore, pulses are to be sold by them in an un-milled condition that fetches a low price. In the absence of any procurement policy of the Government, traders manipulate the situation. They make bulk purchases during the peak season

Most of the pulse growers are forced to sell their market surplus at low prices immediately after harvesting.

at rock bottom prices, but profit goes to traders and not to the producers. There is thus, an urgent need to create an alternative system of marketing.

National Pulses Development Programme in Maharashtra

It becomes obvious in the early eighties that pulse production needed an impetus and the National Pulse Development Programme (NPDP) was introduced. In the implementation of the programme, preference was to be given to small and marginal cultivators, although the NPDP scheme was to cover all farmers. The NPDP scheme was implemented in 11 districts of the state for the pulses of gram and tur. Out of these, six districts were covered for both pulse crops and five districts were covered by the scheme for tur only (Khare, 1995). The NPDP is making slow progress in Maharashtra because only 11 districts are covered under this programme, with the result that the impact of NPDP is hardly visible in terms of technological change in pulse farming. One of the reasons behind slow progress of this programme is that it is being implemented through Government channels without involving the farmers at the grass levels. The efforts of the state are also lacking, as proper attention is not paid to crucial components such as production and distribution of certified seeds, supply of rhyzobium culture and IPM demonstration. In a nutshell, the state does not give due priority to this programme and that is why it is neither properly monitored nor evaluated.

The Pilot Project on Pulses and Oilseeds crops has been implemented from 1989-90 onwards in the state to increase the area and production of pulse crops and there is a good response from the cultivators (GOM, 1999). The productivity of tur and gram increased by 19.2 and 28.3 per cent from 1994-95 to 1996-97. This project has been implemented in twenty districts of the state.

Major constraints

The three major constraints expressed by farmers for loss of yield/low productivity were less rainfall, insect pest attack and soil problems. Besides these, non-availability of good quality seed, plant protection measures, lack of credit support, market distance, water availability, labour, disease and shedding were also reported as major constraints. Major problems of farmers in marketing output were lack of remunerative price, no/inadequate storage facility, fluctuations in market prices, exploitation by market intermediaries, absence of proper grading. The reasons for disposing the product immediately after harvesting were domestic need, to pay off loans, no storage facility and to invest in the next season. The reasons for pulse crop cultivation continuation were it could grow as intercrop, domestic need, less labour requirement, suitable for the soil, to improve soil fertility.

Major economic constraints in increasing pulses production

- A major characteristic of pulse production in the country is that pulses are generally cultivated under rainfed conditions. Of the total area under pulses, less than 7.6 per cent area is under irrigation in the state.
- Non availability of good high-yielding varieties, as in the case of paddy and wheat, was one of the main reasons for slow growth in pulse production. In the majority of cases, old and traditional varieties were grown.
- One of the important characteristics of the existing available varieties of pulses is that, on the whole, the yield per hectare of these crops in the country is very low in relation to other principal crops. The yield of total pulses in Maharashtra is only 460 kg as compared to India's 503 kg per hectare in 2000-02. Even while market prices may be higher for pulses, the overall productivity per hectare for major pulses remain less than other principal crops.
- Due to low income from the pulse crop and high risk in pulse production, farmers are growing pulses as intercrop. Pulses were grown on lower fertility soils or marginal lands. Good quality lands were used at the most for gram that, too, if irrigation was available.
- It has often been argued that no major break through in the development of technology in pulses production has been achieved as the yield per hectare of pulses has practically been stagnating. One of the major yardsticks of adoption of technology is the use of fertiliser in recommended doses. For optimum yield of pulses 30-40 kg of phosphorus and a small dose of 5 to 10 kg of nitrogen is recommended. The average per hectare consumption in selected farms in the state is found to be very low. Some farmers did not know that there is a need for fertilisers, however, some of the farmers gave a heavy dose of nitrogen instead of its low requirements. Farmers used very little fertiliser and pesticides, which are of spurious or inferior' quality.
- Cultivation of pulses is characterised by mixed cropping with coarse cereals. While most kharif pulses like tur, moong, urad etc. are mixed with jowar, cotton, soybean etc. gram crop is generally grown

separately but sometimes it is inter-cropped with rabi crops.

- Pulses are highly susceptible to pest and diseases, which further increases risk in their cultivation. The wilt and pod borers in gram are some of the major diseases of pulses causing considerable damage to yield in various years. It is observed that the expenditure on control of pest and diseases of pulse crops was practically negligible.
- There is a large price spread in the case of pulses as compared to other agricultural commodities as would be seen from the level of prices.
- Seed replacement ratio is very low. The supply of new varieties of seed was limited. Seed was not available at subsidised rates. There is inadequate seed supply of improved varieties to achieve the targeted seed replacement rate (srr).
- The work of grass root level Rural Agricultural Extension Officers was not satisfactory, as farmers could not get any advice from them. There was absence of mobile soil testing units.
- Agro-ecological constraints exist, such as cultivation of pulses in rainfed situation, as more than 95 per cent area under these crops are still rainfed. Farmers do not use even essential farm inputs like fertilisers, irrigation, insecticides and pesticides. In deficient soils, the application of micro-nutrients has been found beneficial but hardly any one uses them.
- Non-availability of proper storage facilities with the farmers and vulnerability of pulse to pests remains a cause of losses in pulses. Processed pulses can be stored for a longer time but small-scale processing units are hardly available with farmers or at the village level.
- Institutional constraints such as less emphasis on transfer of technology related to pulses, human resources development, training, research infrastructure for biotechnological interventions in development of high yielding varieties.

Conclusions and Policy Implications

The problems of increasing production of pulses in the state are confronted with various economic constraints in the form of low yield, income, rainfed condition under high risk situation and low level of technology with poor management. In order to increase the production of pulses, particularly yield per hectare, it would be essential to develop some new high yield varieties suitable to the agro-climatic regions. Efforts will also have to be made to improve the efficiency of marketing so that producers could get their due share in the prices paid by the ultimate consumer. The study brought out certain policy implications.

- To increase production and decrease the productivity gap, efforts are needed to raise productivity through adoption of improved technology with effective extension education. Research efforts of universities should be directed to stabilise the yield of pulse crops.
- For the realization of better yield under irrigated conditions as compared to rainfed conditions, measures should be taken to increase area under irrigation.
- Research efforts should be intensified further to develop disease resistance of high yielding varieties suitable to the agro-climatic conditions of the region.
- At present, there are big gaps between minimum support price offered by the government and the wholesale prices of pulses which are not comparable to the market price indicating that the farmers are not getting the real price for their produce. This gap should be minimised.
- Assured procurement of pulses and dal from mills/processing units.
- There is a need to include all the pulse crops under a crop insurance scheme.
- The seed replacement ration is less than the desired level. The close linkages and interactions among research institutes, seed producing organisations/companies and development agencies may ensure better seed replacement ration.
- Efforts should be made by the extension agencies to convince the farmers to intensify the use of fertiliser and pesticides and proper guidance should be given to the growers for applying these inputs.
- Lack of awareness among cultivators about cultural practices such as seed treatments, method of sowing, application of plant protection chemicals suggest that efforts should be directed towards apprising the farmers of appropriate techniques and measures to overcome them.
- Financial assistance should be given to pulses growers for applying fertilisers and pesticides.
- Rhizobium is the cheapest yield augmenting input but farmers are not aware of it. The

rhizobium culture should be provided as a component of the seed packet.

- Farmers are not properly educated/trained about the improved production technology of pulses, farmers need to be convinced about the enhanced profitability of growing pulses through improved method. For this, extension support needs to be strengthened.
- Integrated Pest Management (IPM) needs to be emphasised in pulse crops. Incorporation of Bt gene to control pod borer, disease (wilt and virus) resistance gene, development of rhizobium stains will help in stabilising the productivity. This research should be strengthened (GOM, 2002).
- Identifying potential cropping patterns, with location specific, high yielding, short duration varieties of pulses, which could be fitted in between seasons, would be a better tool for increasing pulse production.
- To increase production of pulses, emphasis will be given to popularization of bio-fertilizers and bio-pesticides and diverting area from crop viz., cotton, wheat etc. Special efforts will be made to bring more and more area under intercropping of pulses (GOM, 2003).

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Book Reviews

Water Perspective, Issues, Concerns *by Ramaswamy R. Iyer,* 2003, Sage Publications India Pvt Ltd., p. 368, Rs. 550.

This book discusses and analyzes several inter-linked themes related to crucial aspects and many dimensions of water resources. There are six sections covering a wealth of topics including:

Water resources in India's federal framework; the adequacy or otherwise of constitutional provisions to resolve inter-state water disputes; given the rigid positions of the state governments and the perceived risks of compromising on those positions, how an agreement is to be brought about. This requires a campaign in the two both states of Karnataka and Tamil Nadu by persons of goodwill. At the same time, it is necessary to rescue public opinion from the miasma of error, confusion, prejudice and anger that has tended to cloud it, and create a climate which is favourable to the acceptance of a reasonable settlement, whether it results from conciliation or adjudication. There is a critique of the National Water Policy 2002 and the deficiencies that persist in calling for revisions. The book also talks about the environment, ecology, sustainability, equality, social justice, conservation, participation, role of women, involvement of stakeholders and so on. Attempts can also be made to ensure that the deficiencies in national policy are rectified to the extent possible in the state policies that are to follow.

The different ways in which water resources are perceived, and whether there is a need to fashion a national water law. Keeping in view, the need to integrate and harmonize the various perspectives as inter-linked and ineluctable parts of one all-embracing perspective. Perhaps a recourse to the rich, multi-faceted Indian notion of dharma as an overarching, all embracing moral order-may be found useful. However, this is merely a tentative idea or philosophy that needs to be worked out carefully and in detail.

The controversies surrounding large-dam projects in India; a critique of the Supreme Court's recent judgment concerning the Sardar Sarovar Project; and an examination of the relationship between the government of India and the World commission on Dams. The dilemmas of Water Resource Development and Narmada judgement. The present notes are merely to explain whether, and if so, to what extent authors' thinking on the subject has changed over the years.

The recent trend of discussing scarcities and conflicts relating to water resources in the language of security, and the fallacies and dangers implicit in that discourse. This chapter sounds a caution against the importance of the language of security into discussions of the scarcity of water and other natural resources, and deprecates the theory of water wars. There is no particular reason why possibilities of cooperation, harmony and integrated development should be discussed under the rubric of security.

Conflict-resolution with reference to the water treaties India has entered into with its neighbours. This chapter is about conflict-resolution in South Asia in the area of water resources. It is structured around three Treaties: The Indus Treaty of September 1960 (India-Pakistan), the Mahakali Treaty of February 1996 (India-Nepal) and the Ganga Treaty of December 1996 (India-Bangladesh). It covers very briefly the background to, and nature of, the dispute in each case, the approach to a resolution, the major features of the treaty, the manner in which it has been operating, the difficulties encountered, how these can be resolved, etc. It then proceeds to set forth some explanations and reflections that arise from these cases. The governing perceptions and other operative factors, as well as the issues that came up, rather than the details of treaties, is the primary concern.

Ways to minimize, if not eliminate, the dilemmas that face water resource management in India, and whether or not various river-linkage schemes should be implemented. Some of the major steps for managing are shifting the focus from water resources development

to water resources management, where a big project is put forward as necessary, make the planning interdisciplinary from the start, with all environmental, ecological and human concerns fully internalized and put it through a stringent process of comprehensive and rigorous evaluation, make the EIA a truly independent and professional activity backed by a statute, a professional code, disbarment provisions, etc., under the supervision of a statuary Environment Regulatory Authority; distance the EIA (and payments for it) from the project planners and approvers and transform the cost-benefit analysis into a careful, comprehensive and sensitive multi-criteria analysis, give primacy to the affected people, make them part of the planning and decision-making process from the start, and give them the first rights over the benefits of the project, adopt the 'rights and risks' approach and the principle of 'free, informed prior consent' recommended by the WCD, with such practical modifications as may be found necessary. The approach and procedures suggested will, of course, apply to future decisions, but there is an existing backlog of completed and current projects where the environmental and human impacts have not been fully recognized or properly dealt with.

The author of this book has put tremendous effort in providing a comprehensive text for the students and valuable guide to all those interested in studying in the fields of water resources, hydrology, environment studies, development studies and public administration. With its lucid coverage of numerous topics of seminal and topical importance marked by original and unconventional thinking, it will serve as a useful guide, handy reference and a rich source of information to researchers, policy and decision makers, administrators, planners and the media.

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Solid Waste Management *by Iqbal H. Khan* and Naved Ahsan, CBS Publishers, p. 238, Price Rs. 175.

The textbook on "Solid Waste Management" is for undergraduate & postgraduate students of Environmental Engineering. The book throws the light on primarily on management aspects of municipal solid wastes right from the source of generation to final disposal through intermediate steps such as collection, handling, transportation and processing. The book covers these aspects comprehensively from experience of solid waste management in Delhi in particular. In addition, the hazardous and hospital wastes management and Environmental Impact Assessment (EIA) have also been touched upon briefly for basic understanding of the environmental engineering students.

In chapter 1 the the impacts of solid waste disposal on environment are discussed very briefly. As several studies are carried out in the past world over, some findings could have been included in the book. The composition of solid waste and physical and chemical analysis have included based on data available from CPCB and ISEM in 2000. It appears that the data has not been authenticated based on their field studies.

The tools and techniques for handling, collecting, transferring and processing and discussed in chapter 2. These aspects have been discussed based on available literature and illustrated based on the practices followed in Delhi, wherever applicable. The thrust has been given on municipal solid waste processing through different technologies such as thermal, chemical biological processing (Aerobic, aerobic conversion). The operating parameters of each type of processing have also been provided.

Chapter 3 covers disposal of municipal solid waste in sanitary landfills. The design and operating requirements of engineered landfills have been discussed. The other aspects covered include:

- environmental monitoring of landfill
- Landfill specifications
- Layout of landfill site
- Components of liner system

The leachate generated from landfills is required to be managed scientifically. The characteristics of leachate and its management system including treatment have been discussed in chapter 4. Estimation procedure of leachate quantity through water balance method and computer model 'HELP' (Hydrologic Evaluation of Landfill Performance) have been given. The liner material types and their specifications are also included.

Chapter 5 discusses the control of gas generated from landfills due to decomposition of carbon present in waste. The following aspects of landfill gas management are provided in this chapter:

- Quantitative estimation of landfill; gas generation
- Composition
- Stages of landfill gas generation
- Landfill gas migration pathways

- Gas collection
- Monitoring and detection

Management of Hazardous and Hospital wastes, site remediation and Environmental Impact Assessment (EIA) have been given in chapter 6 and 7. The salient features applicable rules are also given. The EIA methodology and various steps in conducting EIA studies such as baseline studies, prediction and evaluation of impacts and environmental Management plan are discussed.

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Experiments in Food Process Engineering *by H. Pandey, H.K. Sharma, R.C. Chauhan, B.C. Sarkar and M.B. Bera,* CBS Publishers and Distributors Daryaganj, New Delhi-2, p. 312, Price Rs. 295.

Amidst plethora of books flooding the market in the field of computers and management it is not only encouraging but also refereshing to sight a book from Indian authors in the area of food processing. Along with communications and power, food processing has been identified as one of the sunrise areas of the Indian economy. As such books in this area relevant to Indian academic requirements is the need of hour and it is a laudable effort from the publishers.

Though the authors claim in the preface that the target group include, technocrats and scientists working in the area of food processing, a glance through the book indicates that it is basically meant for students and teaching community. Especially the under graduate engineering students specializing in food processing and other food science students who want to master the basic concepts food engineering can take great advantage of this book.

The book is divided into twenty chapters focusing on laboratory safety, units and dimensions and their conversion, mass and energy balance, colligative proprties and surface tension, fluid flow in foods, rheological properties of food materials, pumps and fans, heat transfer in foods, heat exchangers, thermal processing in foods, application of psychrometric chart, equilibrium moisture content and water activity, drying and dehydration, mass transfer, food grain properties, size reduction and screening, refrigeration, freezing, packaging of foods and food storage. Each chapter contains brief description of basic concepts, few experiments followed by viva-voce questions and lab problems. While this approach is systematic, number of lab problems provided should have been more for the much needed practice of the students. Presumably these become a casualty because of large number of chapters involved and the time limitations usually encountered by the laboratories.

A self contained appendices section is providing all the necessary information such as units, tables etc. So the users especially students and the teachers need not run around for locating the tables, formulae and units. Other added attraction is a chapter with multiple choice questions, to test and brush up your knowledge of fundamentals of food process engineering. This chapter comes in handy for those appearing for entrance and other competitive examinations in the field of food engineering. While the book has covered most of the topics required to grasp the basic practical aspects of food process engineering, no attempt has been made to introduce emerging areas especially in the quality front. Chapters on popular topics like Hazard Analysis Critical Control Point (HACCP) and application of ISO 9000 in food processing would have made the book more comprehensive and authors may give due consideration to these topics in future editions.

The book also contains enough illustrations and figures for better understanding of the topics. However the book contains no photographs of the lab instruments/equipment used in the experiments, which would have helped the users further. It is reasonably priced and within the reach of libraries, teachers and students who are the main target group. Overall the book is a welcome arrival for those involved research, education and training in food processing.

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News & Notes

Total Factor Productivity Growth (%) refers to the growth in real GDP per unit of labour and capital combined.

Table 1: Total Factor Productivity Growth (%)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Bangladesh	0.93	0.21	–0.39	–0.24	–1.06	–0.41	–1.29	–1.63	0.24	–0.77
Republic of China	0.11	0.18	–0.14	0.04	2.67	1.91	0.33	1.62	1.39	–2.11
India	2.73	0.86	3.62	2.73	3.16	1.24	3.09	3.06	2.85	3.06
Japan	–1.38	–1.36	–0.45	1.18	2.05	0.45	–1.13	0.27	2.39	0.52
Republic of Korea	1.41	1.46	2.50	3.99	2.33	2.32	–2.36	7.87	3.15	2.02
Malaysia	1.16	2.53	2.26	2.84	2.54	1.66	–5.69	3.22	4.84	–1.41
Nepal	0.07	4.57	–0.65	1.79	0.88	–0.80	0.27	1.41	0.42	–2.58
Pakistan	3.58	–1.93	1.20	3.39	3.39	–3.63	–1.07	1.61	3.87	–0.19
Singapore	–0.77	4.16	3.11	–0.94	–2.94	–1.18	–8.87	0.49	1.01	–5.77

Capital Productivity Growth (%) refers to the growth in real GDP per unit of capital input

Table 2: Capital Productivity Growth (%)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Bangladesh	–1.26	–2.07	–2.81	–2.43	–3.14	–8.16	–8.03	–7.88	–0.28	–6.18
Republic of China	–1.94	–2.67	–2.26	–2.60	–1.94	–1.70	–3.58	–1.99	–1.70	–0.03
India	0.56	–4.51	0.06	–1.94	–1.51	–1.98	0.14	0.70	2.50	1.55
Japan	–3.71	–3.73	–2.98	0.03	0.26	–0.18	–2.36	–1.02	1.40	–0.15
Republic of Korea	–5.31	–4.55	–2.51	–1.72	–3.41	–2.73	–9.58	5.60	3.79	–0.68
Malaysia	–4.14	0.27	–3.47	–2.79	–2.22	–4.21	–11.48	2.22	2.90	–4.01
Nepal	–1.64	3.37	–1.86	0.61	0.10	–1.54	0.14	1.27	0.21	–4.41
Pakistan	2.55	–3.47	–0.34	0.47	1.87	–2.26	0.04	1.03	0.74	–0.84
Singapore	–0.77	4.16	3.11	–0.94	–2.94	–1.18	–8.87	0.49	1.01	–5.77

Labor Productivity Growth (%) refers to the growth in real GDP per person employed

Table 3: Labour Productivity Growth (%)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Bangladesh	1.89	1.20	0.66	0.71	–0.15	3.12	1.74	1.18	3.17	1.63
Republic of China	2.21	3.11	2.03	2.74	7.49	5.64	4.40	5.35	4.57	1.97
India	4.41	5.12	6.40	6.42	6.84	3.74	5.37	4.90	3.12	4.21
Japan	–0.13	–0.08	0.90	1.79	3.00	0.79	–0.47	0.95	2.93	0.89
Republic of Korea	4.46	4.23	4.81	6.55	4.70	4.43	1.15	9.07	2.80	3.39
Malaysia	4.70	4.00	6.10	6.62	5.70	5.60	–1.79	3.86	6.10	0.29
Nepal	1.48	5.65	0.49	2.94	1.62	–0.18	0.37	1.53	0.59	–1.12
Pakistan	4.03	–1.26	1.86	4.67	4.05	–4.21	–1.54	1.86	5.24	0.09
Singapore	3.18	11.14	7.54	4.69	5.30	3.63	–2.94	5.51	–1.51	–0.08

Table 4: Labour Productivity Growth in Agriculture Sector (%)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Bangladesh	–0.25	–0.19	–1.83	–2.94	0.37	4.63	1.87	3.40	6.00	1.81
Republic of China	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
India	6.58	4.90	5.79	–0.13	10.42	–1.71	6.99	1.06	0.35	6.44
Japan	5.24	–3.76	5.32	–3.94	6.46	–3.67	–1.44	–3.74	3.83	3.56
Republic of Korea	11.78	0.44	4.56	14.92	7.75	6.55	–10.18	11.24	4.67	6.27
Malaysia	4.50	3.20	2.90	5.31	4.58	4.57	–0.66	4.01	0.52	2.29
Nepal	-1.36	6.96	–1.98	2.29	2.23	–1.34	0.04	1.77	2.76	2.09
Pakistan	3.99	–6.51	–2.41	13.51	9.08	–0.07	–7.10	–0.31	4.84	–4.77
Singapore	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note: Agriculture sector includes agriculture, forestry and fishing

Table 5: Labour Productivity Growth in Industry Sector (%)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Bangladesh	2.34	1.67	3.58	2.82	–2.43	2.18	3.04	1.28	2.45	2.85
Republic of China	3.63	3.70	3.14	6.42	6.32	5.31	3.05	4.84	4.52	–1.04
India	–0.18	0.96	4.78	7.88	2.55	–0.19	–0.78	0.17	1.80	–1.39
Japan	–2.71	–1.43	–0.75	3.12	3.71	1.54	–0.73	2.95	6.08	–1.18
Republic of Korea	4.60	9.21	7.13	7.15	7.61	8.12	9.70	12.72	5.36	3.91
Malaysia	1.32	4.49	4.72	7.68	2.13	2.35	–2.65	6.63	8.86	–1.80
Nepal	–9.05	–5.80	–9.17	–5.83	–8.26	–11.82	–8.88	–6.49	–10.98	–7.50
Pakistan	5.00	4.61	8.56	–1.87	2.12	–8.01	11.65	2.45	–2.55	0.33
Singapore	4.34	10.53	13.20	10.75	8.38	3.82	1.21	8.53	–17.68	–26.45

Note: Industry Sector Includes mining & quarrying, manufacturing, utilities, and construction

Table 6: Labour Productivity Growth in the Service Sector (%)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Bangladesh	1.23	0.67	0.32	–0.32	–1.63	1.61	–0.54	–1.41	1.44	–0.36
Republic of China	0.12	0.85	0.75	–1.66	7.09	6.90	5.08	5.49	3.83	4.03
India	2.55	4.50	3.81	7.18	3.90	6.36	4.91	6.59	1.13	4.32
Japan	1.30	0.34	1.22	1.53	1.69	0.92	0.00	0.50	0.66	1.82
Republic of Korea	2.23	–0.87	1.45	3.20	1.27	1.32	–0.71	5.19	–0.62	255
Malaysia	3.04	6.64	4.15	5.18	6.97	6.08	0.27	1.85	3.82	3.16
Nepal	2.82	2.47	1.16	0.98	–0.50	1.31	–0.30	–0.16	–0.04	–2.35
Pakistan	5.10	–3.10	5.62	–2.33	2.48	–8.36	0.20	2.69	12.02	2.55
Singapore	2.33	10.83	5.48	2.75	3.97	4.73	–4.25	3.66	5.24	–7.70

Note: Service Sector Includes trade. restaurants & hotels, transport & communications, financial & real estate and community & social services. □

Strength does not come from physical capacity. It comes from an indomitable will.

– Mahatma Gandhi

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