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Contents

Human Capital for the Proliferation of e-governance in the Indian Police

R.K. Mitra & M.P. Gupta

E-governance in police administration refers to a techno-savvy police system which requires a combination of policing and Information technology (IT) skills. It is observed that 'police', as an organ of Indian civil administration has received little attention in the matter of its endeavour to embrace IT. The age-old colonial image of police and relative lack of transparency in its operations contribute to it remaining 'distant' from the main civil administration. This paper studies the importance of human capital that is required for the proliferation of e-governance in the Indian Police.

R.K. Mitra is Deputy Secretary, Govt. of India and Dr M.P. Gupta is an Associate Professor, Department of Management Studies, Indian Institute of Technology Delhi, Hauz Khas, New Delhi, India

Digital government or e-government, often used interchangeably, is not just putting public services on line 'it is about government harnessing IT (information technology) to redefine its 'social technologies' in order to remain relevant in a more interactive and more informational era (Tapscott & Agnew, 1999). Nonetheless, the deployment of IT, both in and across public sector organizations is driven by a variety of factors, and it may face resistance (Kaylor et al. 2001, Petrovic 2004, Junio-Sabio 2004, and Kumar et al. 2004).

For reasons ranging from size, scope and operational complexity, national governments may be particularly resistant to cultivating the required shifts in skills, values and vision. Yet, a real danger is that in the absence of radical and effective reform, national governments are likely to turn to futile attempts to re-enforce traditional lines of power and authority. A continuing focus on hierarchically-based leadership, partially contradicts the recognition of the need for individuals with new combinations of leadership competencies and abilities associated with delivering in a web-enabled management framework. Yet, the shift towards a new order of "e-governance" (penetrating political, commercial and social spheres) accelerates, bringing at least the possibility of new governance capacities emerging (Allen et al. 2001, Costake 2004, and Bagga 2004).

Civil administration is an institution created by society to bring about stability and at the same time growth and development in society. The Indian police is a part of the said administration and is entrusted with a given set of responsibilities and attendant authorities to execute those responsibilities. It has further created its own executive apparatus in the form of certain organizational units through which it seeks to carry out its given responsibilities. To assist the executive apparatus in accomplishing the assigned tasks, there are enabling legislations, rules and procedures. While there is no dispute about the capability of the IT to overhaul the service delivery apparatus, it is observed that 'police?, as

an organ of the civil administration, has received little attention in the matter of its endeavour to embrace IT.

The age-old colonial image of the police, the relative lack of transparency in its operations, a general sense of 'awe' surrounding the police etc. have all contributed to it remaining 'distant' from the main civil administration. For researchers, e-governance is a new and promising area of research. Up to now there has been a dearth of empirical research on e-governance with regard to the Indian police. The main objective of this study is to understand how field police units are embracing e-governance in improving their internal work processes and also service delivery to citizens.

The age-old colonial image of the police, the relative lack of transparency in its operations have contributed to it remaining 'distant' from the main civil administration.

E-governance in Indian Police: Research Issues

India has not remained insulated from the impact of IT. Way back in 1975, the National Informatics Centre was set up by the Government of India with the avowed objective to promote IT in managing the internal processes of Government departments (Gupta et al. 2004). E-governance development in India can be broadly divided into two main phases. The first phase is from the 1960s to the 1990s and the second phase starts from the late 1990s. In the first phase, the government concentrated on the use of IT essentially for internal administration purposes of central government departments such as defence, research, economic monitoring, and certain data intensive functions, such as elections, national census and tax purposes. In the late 1990s there was a significant shift in the thinking and approach towards IT and the emphasis turned towards using it not only for internal functions but also for reaching out in an effective manner to the rural as well as urban population. This phase was marked by the formation of the National IT task force and the State Government IT policies. The phase also saw the involvement of NGOs as well as the private sector in providing services to the public. The Government has since created a separate Ministry of IT in 1999 and approved the IT Bill in 2000, which has given legal recognition to electronic documents. It facilitates online transactional services on the Internet.

India's Tenth Five Year Plan (2002-2007) of India adopts a broad framework of governance (Planning Commission of India 2002) and has approved a National E-Governance Action Plan (NEGAP). This framework constitutes three distinct but highly interrelated layers of deliberate arrangements. Firstly, 'institutions' that society has created to achieve certain objectives; secondly, the executive apparatus adopted or evolved by the institutions for implementing the objectives for which the institutions have been created; and thirdly, a framework of legislation, rules and procedures formulated for delivering and meeting the responsibilities of the institutions. It has been suggested that an India portal be developed – a portal of all government websites for providing a one-stop, non-stop delivery of public services and dissemination of services. NEGAP seeks to create the right governance and institutional mechanisms, set up the core infrastructure and policies and implement a number of Mission Mode Projects at the centre, state and integrated service levels to create a citizen-centric and business-centric environment for governance. Emphasis is given on private partnership. The Government has also approved the policy of allocation of 2 to 3 per cent of the budget for IT. There are some interesting experiments of e-governance undertaken at the state level in India, which bears testimony to the fact that IT is being conceived as an important agenda of public administration in India. However, there is still a long way to go.

Why Police Administration?

The Police in India has different variants. The Indian Republic is federal in structure – there is a the Union Government at the Centre and there are federating States and their governments. The Constitution of India has three distinct categories: the Centre, the State and Concurrent Lists. The subject 'Police' is in the seventh schedule of the Constitution and as such it is a subject allocated to the State. The police is a State subject and its organization and working are governed by rules and regulations framed by the State governments, which are outlined in the Police manuals of the State police forces. Each State and Union Territory has its separate police force.

The police is a State subject and its organization and working are governed by rules and regulations framed by the State governments.

Despite the diversity of the police force, there is a good deal that is common amongst them. This is mainly due to the fact that the structure and working of the State Police Forces are governed by the Police Act of

1861, which is applicable in most parts of the country and major criminal laws, like the Indian Penal Code, the Code of Criminal Procedure, the Indian Evidence Act etc. are uniformly applicable to almost all parts of the country and an integral part of the country?s Criminal Justice System. The Indian police is a legacy inherited from the British and some of the colonial attributes are still evident.

There are 13 levels in what is called the police hierarchy in the civil police administration managed by each federal state. The head of the police force in the State is the Director General of Police (DGP), who is responsible to the State government for the administration of the police force in the State and for advising the government on police matters. States are divided territorially into administrative units knows as districts. An officer of the rank of Senior Superintendent of Police (SSP)/Superintendent of Police (SP) heads the district police force (District Police Chiefs). A group of districts form a range, which is looked after by an officer of the rank of Deputy Inspector General of Police (DIGP). Some States have zones comprising two or more ranges, under the charge of an officer of the rank of an Inspector General of Police (IGP). Every district is divided into sub-divisions. A sub-division is under the charge of an officer of the rank of Assistant Superintendent of Police (ASP)/Deputy Superintendent of Police (DSP). Every sub-division is further divided into a number of police stations, depending on its areas population and volume of crime. Between the police station and the sub-division, there are police circles in some States ' each circle headed generally by an Inspector of Police. The State Police structure can generally be portrayed as given in Fig. 1.

	Level Number for identification*
Director General of Police (DGP) {Incharge of the State Police Force}	P1
↓	
Additional Director General of Police (A DGP)	P2
↓	
Inspector General of Police (IGP) {Incharge of a zone, which comprises few ranges}	P3
↓	
Deputy Inspector General of Police (DIGP) {Incharge of a range, which comprises a group of districts}	P4
↓	
Senior Superintendent of Police (SSP) {Incharge of the bigger District)	P5
↓	
Superintendent of Police (SP) {Incharge of the District}	P6
↓	
Additional Superintendent of Police (ASP)	P7
↓	
Assistant/Deputy Superintendent of Police (ASP/DSP) {Incharge of a Sub-division in the district}	P8
↓	
Inspector of Police {Incharge of a Police Station}	P9
↓	
Sub Inspector of Police (SI) {Incharge of a smaller Police Station}	P10
↓	
Assistant Sub-Inspector of Police (ASI) {Staff of the Police Station}	P11
↓	
Police Head Constable (HC) {Staff of the Police Station}	P12
↓	
Police Constable {Staff of Police Station}	P13

*Hereafter these levels will be referred in bracket for identification.

Fig. 1. State Police Structure

Functionally as well as organizationally, a police station is the basic unit of police administration through which both crime (as enunciated in the Indian Police Act, 1861) and non-crime duties are discharged. Crime duties denote all those jobs which the police do in crime investigation and preparing prosecution documents. Non-crime duties denote all kinds of duties other than those directly related to crime investigation. To give examples, community policing, rescue and rehabilitation, prevention of abuses at public places, deployment during festivals etc. are some of the examples of non-crime jobs of the police. Police stations are the places where complaints and First Information Reports (FIRs) are lodged. Police stations also serve as the window of 'citizen interface' for the police. Common people approach police stations for assistance. Both the Central and State governments have been improving police stations in terms of physical form, their functioning, enhancement of skill and behavioural pattern of the police personnel. Organizationally, police stations occupy the centre stage of attention from the top administrations. Attention of media, non-government organization and the judiciary often remains focused on police stations.

There has been significant growth in police manpower since lindependence. On January 1, 2003, the total strength of the State Police Forces was 1,468,776 out of which the civil police constituted 1,120,167 and the armed police 348,609. Percentage wise, the civil police accounts for 76.27 per cent and armed police accounts for 23.73 per cent. During the period 1947-2003, the police strength registered an increase of 280.5 per cent. The civil police increased by 351.9 per cent, the armed police by 161 per cent.

The police strength varies from State to State. While Maharashtra had the largest police force (150,176), Dadar and Nagar Haveli had the smallest contingent

(only 213 persons). In the hierarchical structure, base of the police organization is very heavy, with constabulary (P12, P13) accounting for about 87.61 per cent of the total strength (Fig. 2). The upper subordinates (P9 to P11) constitute about 11.51 per cent of total strength. Higher level officers from the rank of Deputy Superintendent of Police (DSP) (P8) to the Director General of Police (DGP) (P1) account for less than 0.88 per cent of the total police strength. Expenditure incurred on State Police Forces has been rising every year. During the period from 1990-91 to 2002-2003, the total expenditure incurred on police forces in different states registered an increase of about 280.06 per cent.

Maharashtra had the largest police force, Dadar and Nagar Haveli had the smallest contingent.

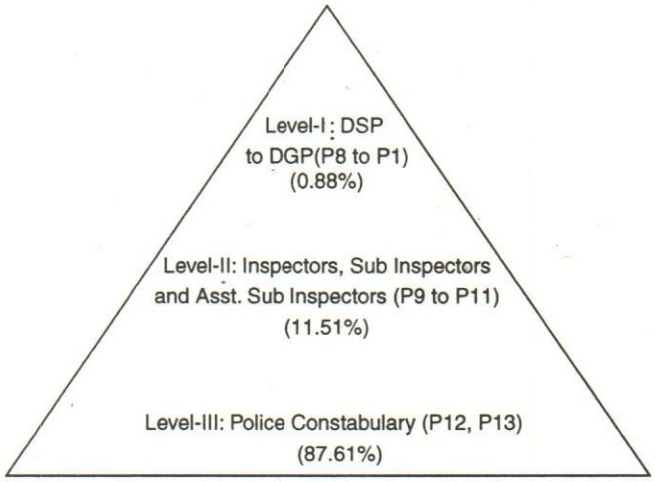

Fig. 2. Indian Police Pyramid

The Central Government has shown sharp, keen and constant interest in the modernization of the State police and has been granting sizeable funds to the States for this. Police Reform is an important component of the Government's agenda on administrative reforms. Way back in 1970, the National Police Commission (known as Dharamvira Commission) was set up to make a comprehensive review of the police system at the national level. Since then, a number of committees and commissions have specifically been set up to go into the various aspects of police reforms. In other words, police functioning has remained a constant area of governmental concern and efforts have been on to improve upon it. However, the Indian police is yet to be free from the colonial mindset as aptly reflected in the following lines that appeared in the terms of references of the Padmanabhaiah Committee set by the Government of India in 2000.

> "The Police is very fast losing its credibility and dependability. The gap between public expectation and the police performance is widening every day. The common citizen fears the police and avoids taking its help, whereas criminals violate the law of the land with impunity. The system which still functions in colonial mould needs to be revamped, so as to make it more reassuring, public friendly and effective in dealing with the criminals and anti-social elements and to meet the requirement of the new millennium."

The use of the phrase 'requirements of the new millennium' hinted at the need for a new role of the police. The National Police Commission (1977) as well as various State Police Commissions have graphically and convincingly delineated the weaknesses in the working of the Indian police. The major weaknesses are:

- The attitude, behaviour and mind-set of the police force;
- Lack of fairness and impartiality in dealing with the public, and especially, in investigation of crime;
- A widely-held perception that it is a force to take care of the interests of the political and social elite;
- Willingness to be manipulated by the party in power;
- Rampant corruption at various levels;
- Non-registration of crime.

E-governance could have brought some relief by bringing transparency to the police work (Mitra 2004). Way back in 1986, the Government of India created the National Crime Record Bureau (NCRB) and mandated it with the task of creating a computer network called the Crime Criminal Information System (CCIS). The CCIS

The National Crime Record Bureau (NCRB) has developed the following e-governance applications systems: Police Station Management System, Prison Statistics, Jail Management Software, Prosecution Branch System, National Bomb Squad System and Forensic Science Laboratory System.

was designed to create computerised storage, analysis and retrieval of crime criminal records. The Crime Criminal Information System today is in operation in all the States. The National Crime Record Bureau (NCRB) has developed the following other e-governance applications systems: Police Station Management System, Prison Statistics, Jail Management Software, Prosecution Branch System, National Bomb Squad System and Forensic Science Laboratory System and The Motor Vehicle Information Counters (MVIC). The first Motor Vehicle Information Counters (MVIC) was opened in January 2001, in New Delhi. By October, 2003, the Bureau attended to 29,282 queries (Annual Report, Government of India, Ministry of Home Affairs, 2002-03) resulting in the discovery of 1,358 stolen vehicles. The system is under installation in 20 more places. Centres are already operating in Ambala, Bangalore, Bhopal, Chandigarh, Chennai, Guwahati, Kolkata, Jammu, Pondicherry, Shillong, Mathura and Gurgaon.

The Bureau has also launched a Firearm Information Centre at its head quarters (HQ) in New Delhi in June, 2002 for the use of general public. A window-based Portrait Building system has been developed and released to State for use. The National Crime Record Bureau (NCRB) actively assists the States in their e-governance programmes apart from directly developing software and releasing this to the States. The Directorate of Coordination Police Wireless (DCPW) is yet another agency connected with e-governance in police. It is the nodal coordinating agency for Police Telecommunication both at state and national level in India. It has the responsibility to provide inter-state communication, training of police radio personnel, providing cryptography cover in police communication networks, coordinating radio frequency and modernization of police communication and acting as a nodal agency to design and implement the National Police Communication Network (called POLNET). The implementation of National Police Communication Network (POLNET) is high on the list of priorities and it is believed that once this secure network exclusively for police comes up, e-governance in Indian police will receive a big boost to proliferate.

To give the right impetus to the National Crime Record Bureau, also created were the state-level Crime Record Bureaux (SCRBx) in various States and District Crime Record Bureaux (DCRBx) in various districts of states. State police administration in the States have acknowledged the importance of e-governance and designated a senior level officer for this purpose. Many IT-savvy, young police officers are taking a keen interest in using IT for improving internal efficiency, better management control and delivery of services.

IT-savvy, young police officers are taking a keen interest in using IT for improving internal efficiency of services.

Despite e-governance having made its entry into the police, one finds a conspicuous absence of documented research work on IT or e-governance in the police in the Indian context vis-à-vis similar works in respect to other civil administration like land records, taxation, municipality, birth and death registration etc. The relative isolation of the police as compared to other government departments, reluctance of mainstream civil administration to take police along, the police generally being averse to publicity, the typicality of police functioning, the veil of security, sensitivity and lack of transparency of the police, a general sense of awe associated with the police, difficulty in getting information and data on police and above all a kind of *force mindset* of the top leaders of the police administration etc. seem to have discouraged researchers from working on such a domain. Therefore, an opportunity to work in such a challenging domain apart, a desire to fill an evident gap in research on e-governance has been the key motivating factor in choosing the domain. And finally, the police as a part of civil administration (institution), having its executive apparatus in the form of police stations etc. posed a ready field to synergise the two interests – interest in studying e-governance in its proper context and interest in delving into a domain which is hitherto lesser known.

Research Issue

It is important to understand the budget provisions and the level of IT skills among the police personnel, since these two factors will be very critical drivers of e-governance proliferation in the Indian Police.

IT skill is such a generic driver that it needs no elaboration. However, the issue to be seen is that of the degree of skill. IT skill for all levels is desirable but may not be a necessary condition. Without discounting the importance of IT skill as a key driver, it is possible to indicate some kind of hierarchy of IT skill amongst the employees for a defined set of activities. In the police, crime investigations are done by people of level P10 and P11 and hence, the IT skills of these levels will have a direct bearing on e-governance applications in the field of crime. The finer issue of differential skill component has significant implications in the matter of designing training schedule and allocating resources.

Research Proposition 1: IT skill of police personnel would contribute to advancement of e-governance in both crime and non crime application areas.

After initial automation of human-executed works comes the new ICT-based information process which needs to be executed as well. The new method of processing under an e-governance initiative needs competencies of the people who would operate it and execute the delivery of the intended services. A constable of police engaged in an investigation of a robbery must know how to retrieve information from the database and how to use a decision support system available at the system. An e-governance initiative which addresses this aspect of internal competencies has a definite chance of survival and continuity.

The IT budget is a critical indicator of organizational importance being given to e-governance. This again depends on the level of support and acceptability that is being accorded to e-governance.

Methodology

The choice of research method influences the way in which the researcher collects data. We have employed a questionnaire survey: This is used primarily to collect data relating to the extent of e-governance, application areas and importance of training.

In keeping with the scope of the research, questionnaires were meant for district police chiefs ' Senior Superintendents of Police (SSPs)/Superintendents of Police (SPs) (P5 and P6) who head the district civil police forces and are primarily responsible not only for normal police functioning but also for the implementation of e-governance in the whole of district police administrations which include their offices and police stations located in the districts. The intermediate levels of officers viz, Deputy Superintendent of Police and Additional Superintendent of Police (P7 and P8) between Senior Superintendent of Police (SSP)/Superintendent of Police (SP) (P5, P6) and police station level functionaries (like Inspectors, Sub Inspectors, Assistant Sub Inspectors, Head Constables and Constables (P9 to P13) are not very relevant for the purpose of calling information on e-governance. The logic of sending a questionnaire to Senior Superintendent of Police (SSPs)/Superintendent of Police(SPs) (P5 and P6) is that they are the custodians of all information – administrative as well as other types pertaining not only to their offices but all offices/units under their control and subordination. All hardware and software to be used in police administration in the districts are routed through them and all kinds of applications and uses are monitored by them. Training of police personnel is also routed through them. They are the key persons to asses the impact of applications on internal efficiency as well as on overall police performance. Thus, they are the main nodal and focus functionary in the district and their

Table 1: About Respondents (N = 156)

Respondents	Percentage
Cadre	
IPS	81.4
Non IPS	17.9
No Response	0.6
Sex	
Male	96.2
Female	3.2
No Response	0.6
Age	
Below 30 Years	3.1
Between 30-40	61.7
Between 41-50	19.8
Above 50	10.8
No Response	4.5
Educational Qualification	
Under graduates	1.3
Graduates-General	13.5
Graduates-Professional	28.2
Post graduate-General	25.0
Post graduate-Professional	16.0
Others	4.5
No Response	11.5
Designation	
SSP	0.6
SP	99.4
Total Experience (Service)	
Below 5 Years	4.4
Between 5-10	41.6
Between 11-15	21.2
Between 16-20	8.9
Between 20-25	5.8
Above 25 Years	6.1
No Response	11.5
Experience in IT	
Below 1 year	14.7
Between 1-5	36.9
Above 5 Years	5.0
No Response	42.9

offices act as the main depository of information of all important aspects of district police administration. Functionaries superior to Senior Superintendent of Police (SSP)/Superintendent of Police (SP) (P5 and P6), like Inspector General of Police (IGP) (P3), incharge of Zone or Deputy Inspector General of Police (DIGP) (P4), incharge of a Range do not have any independent source of information and rely on the information base available with the office of Senior Superintendent of Police(SSP)/Superintendent of Police(SP)(P5 and P6).

The profile of respondents is given in Table 1.

Indicator of IT skill

Seven components of IT skill were identified

- Use of Operating System (eg. Windows, Linux etc.)
- Use of e-mails
- Electronic Spreadsheets (eg. MS-Excel)
- Web Design (eg. HTML)
- Generic familiarity with Networking-file sharing and printing on network.
- Scanning and Backup on CD

Responses were sought to indicate the skill level of police personnel in each of the identified areas of skill in the Likert 5-point scale. Since the category of police personnel was given separately, it became possible to compute indicator of IT skill of each category of police personnel separately.

Analysis of Data and Statistical Findings

Some of the variables investigated here are the extent of use of computers (general) in key organizational units, i.e., office of Senior Superintendent of Police (SSP)/Superintendent of Police(SP) (P5 and P6) and police stations (manned by personnel of P9 to P13) and extent of focus on specific applications. The main statistical trends with respect to use of computers in general are depicted in Figure 3. The main parameter that has been used is mean value of responses (N = 156). Scale used is 5 point scale. 5 (Very High), 4 (Moderate), 3 (Little), 2(Very Little), 1 (None) for Figure 4 and 5 (80 percent to 100 percent), 4 (60 to 80 per cent), 3(40 to 60 per cent), 2 (20 to 40 per ent) 1 (Less than 20 per cent) for Figure 5.

Based upon mean of responses, the main trends which emerge are given Figure 3.

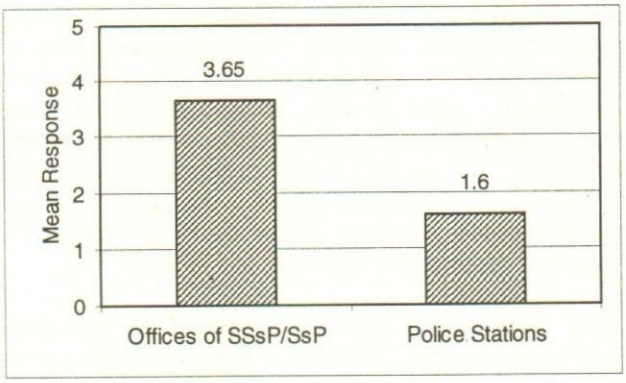

Fig. 3. Extent of Use of Computers (in general) (N = 156)

Between the two organizational units, the extent of use of computers is found to be higher in the offices of Senior Superintendents of Police (SSsP)/Superintendents of Police (SsP) (P5 and P6) as compared to police stations.

Application areas of e-governance

Five application areas were further investigated for differential focus they receive:

- Office Management
- Crime Criminal Administration
- Stock and Material Management
- Information and citizen services.

E-governance applications are more conspicuous in the offices of Senior Superintendents of Police (SSsP)/Superintendents of Police (SP) (P5 and P6) than in police stations. At these offices office management and crime-criminal administration are the dominant areas of application. These trends can be explained in terms of better hardware, software provisions and trained staff. The low use of computers at police stations may be attributable to slow penetration of hardware,

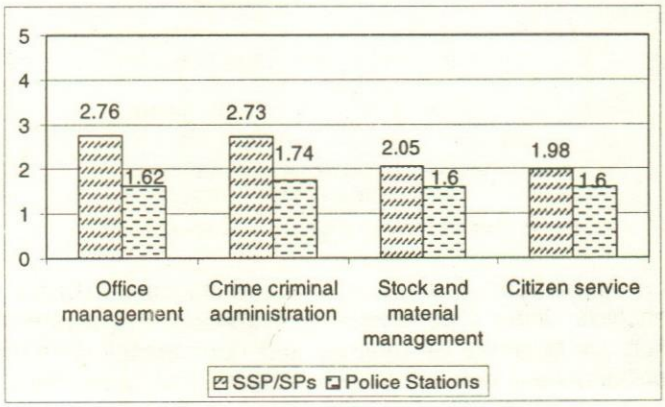

Fig. 4. Application Areas of E-governance

software and absence of trained personnel at police stations. At police stations also, the application areas are confined to crime criminal administration and office management. While crime criminal administration application is attributable to the adoption of Crime Criminal Information System (CCIS) countrywide, the use of office management software is mainly due to availability of various standardized software in the open market. The trends that emerge are depicted in Fig. 4.

As against the present scenario, an interesting result relates to the potential of e-governance applications in various office management, operation management, community and citizen service management areas of police. Information was collected on actual extent of e-governance applications as well as the extent of applications as perceived by the respondents in (identified) different areas.

It is interesting to note that notwithstanding low e-governance applications in most areas as on date, the respondents have fairly good idea as to where and to what extent e-governance applications can proliferate. Figure 5 depicts the position in a grid. As many as ten areas have been assessed as high potential areas of e-governance applications.

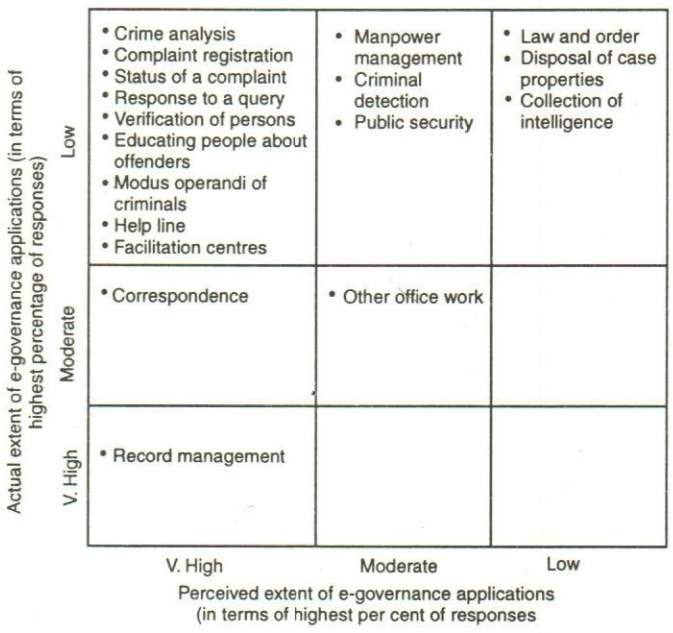

Fig. 5. Potential Use of e-governance Applications

Apart from all areas of Office Management, Crime analysis under Operational Management and a large number of areas of services and community-oriented policing were included in this category. Few areas have been identified as areas with little significance though these areas represent key policing activities. Maintaining law and order, collection of intelligence, disposal of case properties etc. are some of the primary and key hardcore policing jobs. There could be two plausible explanations for identifying these areas as areas of little applications for e-governance. Firstly, the typical nature of these policing jobs and secondly, the lack of knowledge of how IT enablement can improve such activities. Each of these jobs is associated with high degree of sensitivity and confidentiality. These jobs do not represent 'business' or 'service' aspects - traditionally, these jobs are done by policemen physically rather than relying on some secondary means or sources. For example, a law and order problem cannot be tackled except by way of adequate *'bandobust'* (deployment), prohibitory orders, many a times by use of brute force, preventive arrests etc.

To take another example, collection of intelligence is a highly sensitive affair. It requires personal involvement at each stage and cannot just be relied on secondary source without verification: IT dependency for such activities requires a lot of knowledge, research, sophisticated equipments and systems and training as well. As such respondents' assessment of little scope of e-governance applications in these areas can well be attributed to lack of knowledge, lack of use, lack of adequate infrastructure etc. Development of IT enabled modules for such areas can be an answer to bridge the knowledge gap and adoption of new systems in place of traditional ones.

To see if the age and IT experiences of the respondents (SSPs/SPs) have any relationship to e-governance applications, Pearson correlation coefficients have been computed and results are described in the Table 2. The relationship has not been found significant. In other words, age and IT experiences of SSP/SP (P5,P6) have no relationships with e-governance application in any of areas including total use.

Table 2: Relationship (Pearson Correlation Co-Efficient) Between Age and Experience in IT and E-governance Applications in Crime, Non-crime and Total Use.

(N = 156)

	Crime applications	Non crime applications	Total applications
Age	.14	.07	.10
IT Experience	.03	.01	.02

IT skill

It is important to understand that Senior Superintendents of Police/ Superintendents of Police (P5,P6) by virtue of being the head of district police forces, are the only authentic sources of information and data on police

Table 3: IT Skill of Police Personnel*

Personnel	IT Skill				
	Senior Superintendent of Police(SSP)/ Superintendent of Police(SP)	Deputy Superintendent of Police (DSP)	Stations House Officers/ Officers incharge of Police Stations	Sub Inspectors/ Assistant Sub Inspectors	Head Constables/ Constables
Use of Operating System (eg. Windows, Linux etc.)	Moderate to Very High	Little	Little	Little	Little
Use of e-mails	Moderate to Very High	Little	Little	Little	Little
Electronic Spread Sheets	Little	Little	Little	Little	Little
Web Design (eg. HTML)	Little	Little	Little	Little	Little
Generic Familiarity with Networking-file sharing and printing on network	Little	Little	Little	Little	Little
Scanning and Backup on CD	Little	Little	Little	Little	Little

* Little includes responses in point scale 1, 2 and 3. Moderate to Very high includes response4s in 4 and 5.

and police personnel subordinate to them. Deputy Superintendent of Police (DSP) to constables (P8 to P13) – all work under the subordination of Senior Superintendents of Police/Superintendents of Police, and for any kind of training that these categories of personnel attend, the same is routed through the higher officers. Therefore, the data collected is authentic and results can be generalised respondents about IT skill of other personnel would be quite authentic. IT skill of personnel is presented in Table 3.

The trends are too evident. The Senior Superintendents of Police/Superintendents of Police (P5, P6) is the only group which by and large appears good in IT skills - nearly 69 per cent of respondents have the knowledge to operate systems and use e-mails. Many of them are good in spreadsheets. The percentage of respondents falling in the bracket of little skill with respect to web design, networking and file sharing and scanning and back-up, is quite high. As evident from Table 3, the IT skills of subordinate policemen (viz, Station House Officers (SHO)/Inspectors, Sub Inspectors (SI), Assistant Sub Inspector (ASI), Head Constable (HC) and Constable (P9 to P13)) is overwhelmingly little. This read with the Focus Group findings particularly the one relating to knowledge gap, brings out the importance of IT skills particularly of these categories of policemen in adoption and proliferation of e-governance in police.

Research Proposition 1, relates to the importance of IT skills in advancement of e-governance. The proposition is that IT skills of police personnel would contribute to the advancement of e-governance in both crime and non-crime applications areas. The categories of police personnel whose IT skill is being taken into account for testing this Research Proposition are:

- Deputy Superintendent of Police (DSP) (P8)
- Station House Officers (SHOs) (P9)
- Inspectors (P9)
- Sub Inspectors (SI) (P10)
- Assistant Sub Inspectors (P11)
- Head Constable(HC)/Constables (P12 and P13)

The attributes of IT skills which are being taken are same as those shown in Table 3. The relationship between IT skill of each category of specified personnel and e-governance application has been sought to be studied by computing Pearson correlation coefficient for each pair as explained in Table 4.

As is evident, IT skill of all categories of police personnel and e-governance applications in non- crime application areas is found to be significantly positively correlated. So is the relationship between IT skill of each category of personnel and total e-governance applications. However, for crime application areas, the relationship between IT skill of police personnel and e-governance application is found to be significantly positive except for categories of Inspector (P9) and Sub Inspector (P10). In other words, IT skill of these two categories of personnel viz, Inspector and Sub Inspector and e-governance applications in crime application areas are found to be not significantly related. A significantly high positive correlation between IT skill of Assistant Sub Inspector category and e-governance application areas in crime, non-crime and total applica-

Table 4: Relationship of IT Skill of Police Personnel with Crime, Non-crime and Total E-governance Applications.

(N = 156)

IT skill of personnel	Crime applications	Non crime applications	Total applications
DSP (P8)	.17*	.28**	.24**
SHO (P9)	.17*	.32**	.27**
Inspector (P9)	.14	.31**	.25**
Sub Inspector (P10)	.14	.31**	.25**
ASI (P11)	.20**	.36**	.30**
Head Constable/ Constables (P12 and P13)	.18*	.24**	.22**

* Significant at .05 level.

** Significant at .01 level.

tions led us to probe further into the IT skill of which category of personnel is contributing significantly to advancement e-governance in police. This is accomplished by a regression analysis, the result of which is presented in Table 5.

It was found that only IT skills of Assistant Sub Inspector (ASI) (P11) emerged to be contributing to e-governance applications significantly in all areas ' crime, non-crime and total (4 per cent for crime, 13 per cent for non-crime and 9 per cent for total e-governance application). As to why it is the IT skill of Assistant Sub Inspector (P11) only that is found to be contributing significantly to e-governance applications in crime areas, could be due to the fact that it is this category of police personnel that mostly act as Investigating Officers (IOs) in crime cases. This tends to show that IT skill of those of police personnel who are concerned with investigation of crimes at field level would be more an important determinant of e-governance. application in crime areas than IT skill of other categories of personnel.

The research proposition was further probed with an intervening technological variable, namely, technological. The IT skill of police personnel of all categories along with 'networking' as intervening variable was taken to see if they together contribute significantly. The findings are summed up in the Table 6.

It is found that network, which is a technological aspect and IT skill of Assistant Sub Inspector (P11), together contribute significantly to the use and proliferation of e-governance applications in crime (22 per cent), non-crime (24 per cent) and overall (19 per cent) application areas. This result is of great significance. While IT skill is necessary, appropriate technological support in the form of 'network' can contribute to widespread adoption and proliferation of e-governance in the Indian police.

Table 5: Determinants of crime, non-crime and total e-governance applications with help of IT skill of police personnel (stepwise regression)

(N = 156)

Independent variables	Dependent Variables								
	Crime applications			Non crime applications			Total applications		
	Beta	Simple r	't' value	Beta	Simple 'r?	't' value	Beta	Simple r	't' value
IT skill of Assistant Sub Inspector (ASI)	20**	20**	2.61	.36**	.36**	4.82	.30**	.30**	4.02
	Multiple R = .20 R Square = .04			Multiple R = .36 R Square = .13			Multiple R = .30 R Square = .09		

** Significant at .01 level

Table 6: Determinants of crime, non-crime and total e-governance applications with help of IT skill of ASI, with 'Networking' as intervening variable

(N = 156)

Independent variable	Dependent Variables								
	Crime applications			Non crime applications			Total applications		
	Beta	Simple r	t-value	Beta	Simple r	t-value	Beta	Simple r	t-value
Presence of network (1 = presence 0 = Absence)	.25**	.27**	3.29	.34**	.38**	4.80	.32**	.35**	4.33
IT skill of ASI (1 = presence 0 = Absence)	.17*	.20**	2.22	.32**	.36**	4.45	.26**	.30**	3.61
	Multiple R = .45 R Square = .22			Multiple R = .49 R Square = .24			Multiple R = .44 R Square = .19		

* Significant at .05 level.

** Significant at .01 level.

IT training

Training is crucial for skill formation. How 'training' is contributing to IT skill formation of police personnel is an interesting proposition to look at. For the purpose of investigation, training contents were clearly delineated ' while some areas are basic in nature, few are specialized. For example, familiarity with computers, word processing, data entry are basic areas of training, crime analysis and cyber crimes fall into specialized category. As may be seen from Table 7, word processing, data entry and e-mail, are uniformly high in coverage of IT training for all categories of police personnel. Web design and cyber crime coverage of IT training is uniformly low for all categories. Networking and file sharing, database, cyber crimes do exist as IT training components, but coverage seem to be average to low. This indicates that the emphasis is more on basic IT training to begin with.

Table 7: IT Training Contents*

(N = 156)

Contents of IT training modules	Personnel		
	Senior Superintendent of Police(SSP)/ Superintendent of Police(SP) (P5 and P6)	Deputy Superintendent of Police(DSP) (P8)	Others (Inspectors, Sub Inspectors, Head Constables and Constables) (P9 to P13)
Familiarity with computers and World Processing (eg. Windows and MS Word)	**High**	High	High
Data Entry	**High**	High	High
Spread Sheets (eg. MS Excel)	**High**	Average	Low
Presentation	**High**	Average	Average
Networking and File sharing	Average	Low	Low
Database Management	Average	Low	Low
Web Designing (eg. HTML)	Low	Low	Low
Email	**High**	High	Average
Crime Analysis	Average	Average	Low
Cyber Crimes	Average	Low	Low

* Responses in percentage: High (60 per cent and above), Average (40 to 60 per cent) Low (Less than 40 per cent).

As to which kind of institutions catering to IT training needs of police personnel, the trends are depicted in Table 8. As obvious from the above result, majority of the training courses are conducted in police training institutes.

Table 8: Location of IT Training

(N = 156)

Locations	Percentage of responses
Police Training Institutes	70.5
Private recognized training centres	31.4
In-house training at the department only	32.1
Training Centres of other States	14.7
Training Centres of Central Police Forces	9.6
Others	11.5

IT budget

A separate IT budget for Police might play a critical role. The scenario with reference to specific dedicated police IT budget at district is in Figure 6. It is evident from this figure that there is no dedicated IT budget at district/Police Stations level. This indicates that districts just depend on higher formations like Police Head Quarter (PHQ) or National Crime Record Bureau (NCRB)/State Crime Record Bureau (SCRB) for hardware, peripherals, software training of personnel, maintenance etc. Under such a centralized system, subordinate formations are rarely found to take initiative.

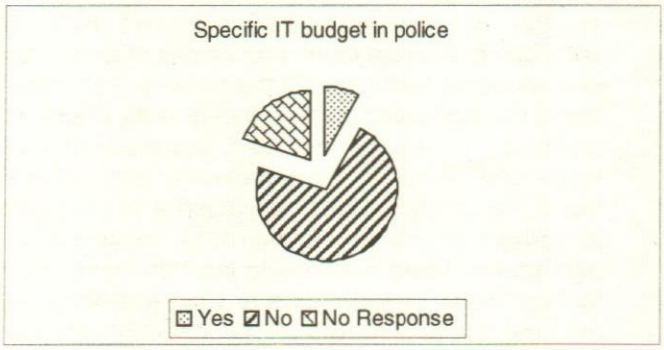

Fig. 6. Specific IT Budget in Police

Enablers of e-governance

A set of factors considered as important for widespread adoption of e-governance in police was identified and respondents' assessment on their importance has been captured on the Likert 5-point scale. The trends are presented in Table 24. Training has been identified by majority of respondents as factors of high importance.

4 Key Findings

Above analysis led to derive the following key findings:

Table 9: Most Important Factors for Widespread Use of Computers in Police Administration

(N = 156)

Factors	Importance (Percentage of responses)
Training/familiarity with computers and its operations	64.1
Availability of customized software	55.1
Support and encouragement to use computers by the superiors	53.8
Availability of computers and peripherals	53.8
Acceptance of Information and Communication Technology work processes to the courts	44.9
Use of vernacular language in computer related works	44.2
Security of the System	42.9
Clear delineation of areas where it can be used	40.4
Authorization by the senior officers on specific areas where computerized work processes can be used to begin with	37.2

- IT has made its presence right in the primary organizational units i.e., police stations (manned by police personnel P9 to P13) as well as in the office of district police chiefs i.e., (offices of Senior Superintendents of Police/Superintendents of Police) (P5 and P6). This is a welcome trend. Impact will be felt soon since police stations and offices of Senior Superintendents of Police/Superintendent of Police being the key police organizationai units where actual police works are originated, organized and implemented. Adoption of e-governance application in those organizational units is indeed a pre-requisite for advancement of e-governance in police organizations. There is a need to push the momentum further. These organizations are more of local administrations and have a 'close' citizenry to serve. E-governance in these organizational units has the full potential to bloom.
- IT skill of cutting edge personnel of police is found to be significantly correlated with e-governance applications. However, IT skill of the category of Assistant Sub Inspectors (ASI, P11) is found to be significantly contributing to overall use of e-governance in police. This is quite possible as it is this category of police officials who are actually involved in crime investigation. IT skill of ASIs along with networking is found to be contributing significantly to the total applications. This testifies that the soft component (IT skill) and hard component 'technology' (networking) both are important enablers for e-governance to flourish. Thus, IT skill formation is as important as technological support. Both must constitute part of the core strategy of e-governance.

The common people generally perceive the police in its traditional role. Non-crime applications bring a ready platform for the police to put forward an altogether different image to the people and towards this end, e-governance offers a ready medium.

Concluding Remarks

It is evident that the Indian Police is facing a tension between age-old colonial role and mindset and that there is a need for transforming as a service provider to serve the people better, to be responsible and transparent. Caught in this phase of transition, the police administration at this juncture as a domain of research poses an excellent research challenge. This paper narrated the investigation on the issues that helped developing an understanding of the status of e-governance in the Indian Police. Although e-governance has infiltrated to the level of police stations, which is the primary unit of police administration, the extent of use is extremely low. However, there is a realisation of e-governance in police functions of these units. IT skill is an important enabler, but skill formation (as seen from the limited coverage of training) seems to be a retarding factor.

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Human Capital, Education Policy and Economic Growth

Bidisha Chakraborty

This paper presents an endogenous growth model where human capital is sector specific and accumulates over time. It has been demonstrated that there exists an optimal tax rate and an optimal share of tax revenue to be allocated between two specific sectors for financing human capital accumulation. Economic growth rate as well as welfare is maximized in the event of the Government pursuing its fiscal as well as education policies, consistent with the growth model.

Bidisha Chakraborty is senior research fellow at the Indian Statistical Institute, Kolkata.

History has shown that modern economic growth has been inspired by a rapid and persistent upgradation of technology and scientific knowledge. Modern growth theory led by Lucas (1988), Romer (1990), Rebelo (1991) and Grossman-Helpman (1991) deals with the endogenously generated economic growth and stresses on the role of human capital accumulation in economic growth. Lucas in his famous paper (1988) considers human capital as an alternative engine of growth to technological change. In that model, a worker with a definite skill level is assumed to devote a fraction of his non-leisure time to the current production and the remaining fraction to the human capital accumulation. All workers in the economy are assumed to be identical. It was assumed by Lucas that while one fraction of the homogenous skilled labour force is employed in the current production, the remaining fraction is engaged in human capital accumulation. In the same paper, he considers another model where human capital is specialized to produce specific consumption goods. Each good is considered as a different industry. Total workforce is allocated within industries in the proportion the goods are demanded by the consumers. In Uzawa's model homogeneous labour has been allocated between educational and productive sectors.

Grossman-Helpman (1990) constructed a dynamic two country model of trade and growth, where they showed that the cross country differences in efficiency at R&D versus manufacturing (i.e, comparative advantage) influence importantly the growth rate of economic variables and commercial policies. But like Romer, Aghion-Howitt they also assumed that a part of homogeneous human capital stock that is employed in the R&D sector is also used in the manufacturing sector and they used the no-arbitrage condition (skilled workers get identical wages in both sectors) to determine the human capital employed in each sector. In our model we have deviated from the assumption of homogeneous human capital stock.

Arthur Fishman, Avi Simhon (2002) mentioned the possibility of division of labour in their model. They showed that division of labour and economic growth are linked with the division of wealth in society. In their model variety of intermediate goods, which are employed to produce output, represents division of labour in the economy. Each variety of intermediate goods is produced by the labour specialised in producing that commodity only. Chari, Hopenhayn (1991) built a model in which each technology requires vintage-specific skills. Murphy, Shleifer, Vishny (1991) developed a model in which they discussed the allocation of talent between rentseeking vis à vis entrepreneurship activities.

It is a very common phenomenon that each worker specializes in one or few functions in the production process. Theoretical arguments dating from Adam Smith have emphasized the importance of specialization of labour. The specialization improves labour productivity by acquiring more efficient and specialist skills and through the saving of time because workers do not have to move from one operation to another. Through the specialisation of labour, economies of scale can also be achieved. Individuals have also differences in efficiency at and preference towards different activities.

In this model human capital is not homogeneous. We have classified human capital broadly into two groups. One type of human capital is employed in only R&D activities and the other type is engaged in manufacturing. While the first group is termed as 'scientists', the second group is termed as 'engineers' in our model. We have assumed that the engineers do not take part in R&D programme and those who have already become scientists do not want to do the job of engineers. We have assumed also that R&D and manufacturing sectors are vertically integrated. Government finances accumulation of both types of human capital. Although they are specific to their uses, if the growth rate is maximized, sector specific human capital gets same wage in balanced growth equilibrium. This happens because of investment in specific form of human capital by government and hence supply is matched with the demand of specific form of skill in equilibrium.

In this model human capital is not homogeneous. While the first group is termed as 'scientists', the second group is termed as 'engineers'.

We did not assume anything about the time needed to become an engineer or a scientist. A person, as commonly seen, needs a few more years to become a scientist compared to an engineer. This involves cost in terms of wages foregone and also in terms of cost of acquiring human capital (in our model this cost is assumed to be zero). Then, the question arises, why do some people go for a doctoral degree while others do not?

Firstly, there are differences among individuals. For reasons related to genetics or to early educational experience some people would like to leave formal education earlier than others. Secondly, some people have special talents for the type of work they do and they prefer to be in the field where they have a comparative advantage. Thirdly, different people put different values on the consumption aspects of education. Those who enjoy the experience of schooling find the cost of foregone income lower. They go for higher education.

Recently Scott Stern (1999) in his working paper has offered convincing evidence that the receipients of Ph.D degrees (scientists) exhibit a strong preference for engaging in the field of science. The preference could be the result of the selection process that attracts people with this taste Ph.D training in science, a training process that cultivates the taste or the combination of the two. Regardless of the mechanism any attempt to make the training of Ph.D students resemble more closely to the training of students in business school could have the effect of significantly undermining the commitment to the ideas and process of science that Stern is able to document. "This commitment, which may be psychologically and functionally similar to the commitment of induced training for membership in a religious order or a military unit, may be critical to the preservation of the institutions of Science."

The role of the government in financing human capital accumulation is well known. Paul. M. Romer in his NBER working paper titled "Should the government subsidize supply or demand in the market for scientists and engineers" (2000) has observed that during the twentieth century, rapid technological progress in US drove the unprecedented growth in output, and that the rapid rate of technological change was fostered by a publicly supported system of education that provided the essential input into the process of discovery and innovation - a steady flow of people trained in scientific method and in the state of the art in their area of specialization. One highly successful example of government policy that did increase the rate of technological change was the creation of the new academic discipline of computer science in the 1960s. Even now, with the passage of 40 years the sense of magnitude of the payoff from this investment is still growing.

Public sector plays a dominant role in almost all countries. Government share in national education expenditure in US, UK, Australia, Belgium, Sri-Lanka and India are 79.5%, 78.4%, 94.9%, 98.1%, 74.2% and 35.8% respectively (Gradstein, Justman, 1996). Even in India the government is now playing a major role in the upgradation of science and technology. On January 6, 2005, the Prime Minister spoke about his intention to set up a Knowledge Commission to look into the issue of building quality human capital. Government believes that investments in institutions of higher education and Research and Development organizations are as important as investments in physical capital and physical infrastructure. The new Science and Technology Policy (STP-2003) declared in the 90th session of the Indian Science Congress (ISC-03) envisages flexible mechanism for the transfer of knowhow to the industry and to enable scientists to receive financial returns. All these policy statements of GOI and other developments substantiate our assumption that the R&D sector and manufacturing sector are vertically integrated.

The Model

An economy consisting of competitive firms, representative household and the government sector is considered. Household consists of scientists, engineers and an infinite unskilled population who are transformed into either scientists or engineers by providing public education. Some firms produce a single homogeneous commodity. The income earned from the sale of that commodity can be consumed, accumulated as capital and paid as income tax. Production of output uses physical capital stock, skill of engineers, technology and assumed to follow CRS with respect to its all factors including technology. Some other firms are engaged in research work. Research and development does not introduce new goods. It simply enhances the productivity of the production process. The production of research output (new knowledge/technology) by scientists is assumed to take the Cobb-Douglas form and uses the skill of scientists and the stock of knowledge already attained. Firms in the manufacturing sector and R&D sector are vertically integrated. Therefore the research outputs are not marketed. It is assumed that the human capital used to produce the final goods (engineers) are different from the human capital employed in R&D sector (scientists). Human capital is a sector-specific and nonshiftable factor. Government finances the accumulation of both types of human capital. The government is assumed to collect the necessary money to finance both types of human capital by imposing proportional tax on final output. There exists a perfect competition in both product and factor market. The rational representative household maximizes lifetime discounted utility.

The firm

All competitive final good producing firms taken together are considered as a single firm. The firm directly uses three types of inputs - technology, physical capital and skill of engineer. The production function takes the form:

$$Y = A^{\alpha_1} K^{\alpha_2} h^{1-\alpha_1-\alpha_2} \qquad ...(1)$$

where $0 < \alpha_1 < 1$ and $0 < \alpha_2 < 1$. A is the level of technology, K is the physical capital and h is the average engineers. In this model Y is assumed to follow CRS technology with respect to its inputs. The output of final goods sector is subject to diminishing returns with respect to each factor keeping all other factors fixed like Mankiw-Romer-Weil (1992). As there is perfect competition in factor market factors are paid according to their marginal productivity. Wage rate per efficiency unit of engineers is

$$w_h = (1 - \alpha_1 - \alpha_2)\,(A/h)^{\alpha_1}\,(K/h)^{\alpha_2} \qquad ...(2)$$

and rent per unit of capital is given by

$$r = \alpha_2\,(A/h)^{\alpha_1}\,(K/h)^{(\alpha_2 - 1)} \qquad ...(3)$$

The remaining a1 fraction of total output goes to the firms employed in R&D and that is shared by the existing scientists working in those firms. The competitive firms producing manufacturing output earns zero profit. The invention of new technology depends on the level of technology already attained and the number of scientists working. The technology development in R&D sector is given by

$$\dot{A} = \delta A^{\beta} H^{1-\beta} \qquad ...(4)$$

where H is the average skill of scientists. The creation of new technology is also subject to diminishing returns with respect to level of technology already attained and the stock of scientists individually but follows CRS with respect to both the factors.

The household

The post tax income of the household can be either consumed or saved in form of capital. Household's budget constraint is given by

$$\dot{K} = (1 - \tau)\,Y - C \qquad ...(5)$$

where τ is the proportional tax rate and $0 < \tau < 1$. Household's utility function from consumption C (t) is given by

$$U(C) = \frac{C^{1-\sigma}}{1-\sigma} \qquad \ldots(6)$$

where $0 < \sigma \neq 1$ so that the constant elasticity of instantaneous marginal utility is $-\sigma$. We assume that the benevolent social planner to be endowed with the same preference function. The common objective of the social planner and the representative household is to maximize the intertemporal utility:

$$\text{Max} \int_0^\infty U(C)\, e^{-\rho t}\, dt$$

where ρ is the positive discount parameter. Household takes price rate, tax rate as given and chooses consumption so as to maximize the discounted sum of utilities subject to (1), (5) and (6). From the conditions necessary for this optimization problem we get the rate of growth of consumption:

$$\frac{\dot{C}}{C} = \frac{(1-\tau)\, r - \rho}{\sigma} \qquad \ldots(7)$$

where r is given by the equation (3). This is the rate of growth from demand side.

Human capital accumulation

Education is the channel through which skilled labour are produced. It is assumed that addition to skill of human capital is directly related to the educational expenditure on acquiring that specific skill. In Lucas' model human capital is a function of the present level of human capital and the time devoted for acquiring skill. But that is also a cost in terms of foregone wage. We assume that the government imposes proportional tax on final output and spends on educational sector (paying wages to teachers, building infrastructure etc.) that produces skill of both types. The tax rate is τ. Let θ and $(1-\theta)$ denote that the fraction of tax revenue used to finance accumulation of skill of engineers and scientists respectively. The more the government spends on human capital accumulation, the more the human capital is accumulated. It may be argued that human capital is not only the function of expenditure but the inputs devoted to that sector. But according to us inputs itself is the rising function of expenditure. So the evolution of human capital stock of both types are given by:

$$\dot{h} = \theta \tau Y \qquad \ldots(8)$$

$$\dot{H} = (1-\theta)\, \tau\, Y \qquad \ldots(9)$$

where $0 < \theta < 1$ and $0 < \tau < 1$

Alternatively it can be thought of as household spending a fraction of its savings to acquire engineering skill and another fraction to acquire the skill of a researcher.

Balanced growth path

A balanced growth path (BGP) of the economy can be defined as one in which all intensive variables (τ, θ) and factor prices are stationary while all extensive variables A, H, h, K, C, Y grow at the constant rate. Let us define a set of new variables.

$$A/h = x,\ K/h = y,\ C/h = z$$

Using equation (8), (9) with h(t) and H(t) growing at constant rates, we have the following relation between h and H in steady state:

$$\frac{h}{H} = \frac{\theta}{1-\theta} \qquad \ldots(10)$$

If on BGP all the extensive variables grow at the same rate then we say that the economy is on steady state BGP. We assume that the economy is on a BGP. Then we can show that the economy is also on steady state BGP.

From the equation (10), (h/H) is constant. From equation (4) if $\frac{\dot{A}}{A}$ is constant then (H/A) and hence h/A is also a constant. From equation (8) if $\frac{\dot{h}}{h}$ is constant then (K/h) is also constant since $\frac{A}{h}$ is constant. From equation (5) if $\frac{\dot{K}}{K}$ is constant then (C/h)is also constant since and $\frac{A}{h}$ and $\frac{K}{h}$ are constants.

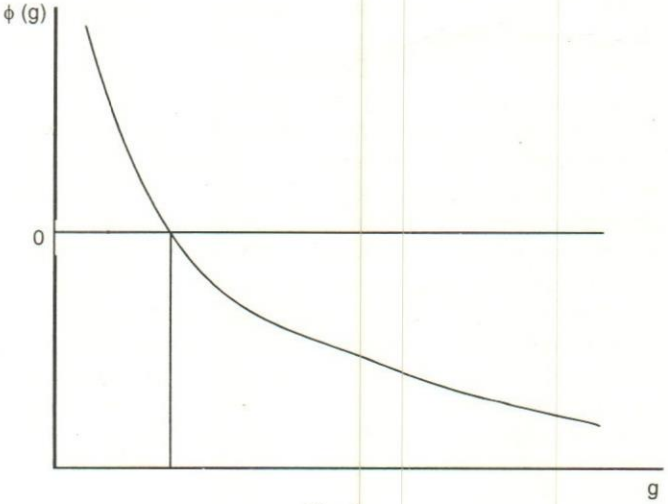

Fig. 1

And, finally from equation (1) Y grows at the same rate as A, K, h grow. Hence the assumption of balanced growth path automatically leads to steady state balanced growth path.

Hence in this model on BGP all variables grow at the same constant rate. Let g be the constant growth rate at which all variables grow on the steady state BGP. Using equations (4), (5), (8), (9) we can solve for the technology engineers ratio (x*), physical capital engineers ratio (y*), consumption engineers ratio (z*) terms of the balanced growth rate g as follows:

$$x^* = \left(\frac{g}{\delta}\right)^{\frac{1}{\beta_1}} \frac{1-\theta}{\theta} \qquad ...(11)$$

$$y^* = \left(\frac{g}{\theta\tau}\right)^{\frac{1}{\alpha_2}} x^{*\frac{\alpha_1}{\alpha_2}} \qquad ...(12)$$

$$z^* = x^{*\alpha_1} y^{*\alpha_2} (1-\tau) - y^* g^* \qquad ...(13)$$

Using equations (3), (7), (11), (12) we get the following equation:

$$g^{\frac{1}{\alpha_2}\left[\frac{\alpha_1}{\beta_1}(\alpha_2-1)\right]} \left(\frac{1-\theta}{\theta}\right)^{\frac{\alpha_1}{\alpha_2}} \frac{\alpha_2}{\sigma} \delta^{\frac{\alpha_1}{\alpha_2(1\beta)}} (1-\tau)\}$$

$$(\theta\tau)^{1\frac{\alpha_2}{\alpha_2}} - \frac{\rho-n}{\sigma} - g = 0 = \phi(g) \qquad ...(14)$$

Left hand side of the equation is termed as ϕ (g) The existence of the balanced growth equilibrium can be seen from the following equations: Since the exponent of g in first term of the above equation is negative and that of the last term is 1, under the assumption $\rho < 1$, i.e. if discount factor is low, $\phi(0) \to \infty$ and $\phi'(g) < 0$.. Hence $\phi(g^*) = 0$ exists and unique. This can be illustrated in Fig. 1.

In the above figure we get monotonically downwardsloping $\phi(g)$ curve in $g - \phi(g)$ plane where $\phi(0)$ is infinitely high.Hence for $g = g^*$, $\phi(g) = 0$ exists for each θ, τ and g^* is unique. The above finding pertaining to the balanced growth rate can be summarized in the following proposition.

Proposition 1 Steady state balanced growth equilibrium exists and it is unique for each θ, τ.

On BGP along with all the variables level of technology (A) grows at the same constant rate g. Hence, using equation(4)level of technology (A) is related to the human capital inherent to the level of scientists(H) in the following way:

$$A = (\delta/g^*)^{\frac{1}{1\beta}} H \qquad ...(15)$$

Using the above equation the production function in terms of both types of human capital and physical capital can be written as:

$$Y = (\delta/g^*)^{\frac{\alpha_1}{1\beta}} H^{\alpha_1} K^{\alpha_2} h^{1-\alpha_1-\alpha_2} \qquad ...(16)$$

Therefore,the share of scientists in total output is α_1 and the share of engineers in total output is $(1-\alpha_1-\alpha_2)$ on BGP.

Optimal policy parameters

To derive optimal values of θ and τ we differentiate equation (14) with respect to the above two parameters. In a very different context, same approach was taken, for instance, by Shieh Jhy-Yuan, Lai Chang(2002). Differentiating equation (14) with respect to θ and equating $\frac{\partial g}{\partial \theta}$ with zero we get that the optimum share of tax revenue to be allocated in financing engineers is

$$\theta^* = \frac{1-\alpha_1-\alpha_2}{1-\alpha_2} \qquad ...(17)$$

The above expression is the ratio of elasticity of output with respect to engineers to the sum of elasticities of output with respect to technology and engineers, which is again nothing but the ratio of share of engineers in total product to the share of human capital (of both types) in total product i.e. Human capitals (of different variety) are financed according to their marginal productivity.

If $\theta^* > \frac{1-\alpha_1-\alpha_2}{1-\alpha_2}$ then $\frac{dg}{d\theta} < 0$.. Again, if $\theta^* < \frac{1-\alpha_1-\alpha_2}{1-\alpha_2}$ then $\frac{dg}{d\theta} > 0$. Therefore, g is maximized when $\theta = \theta^*$.

In the same way we can find out the optimum tax rate and the optimum tax rate is:

$$\tau^* = (1-\alpha_2) \qquad ...(18)$$

i.e, the sum of elasticities of output with respect to engineers and level of technology. This is exactly equal to the share of human capital in total product.

If $\tau^* > (1-\alpha_2)$ then $\frac{dg}{d\tau} < 0$. Again, if $\tau^* < (1-\alpha_2)$ then $\frac{dg}{d\tau} > 0$

Therefore, economic growth rate g is maximized when $\tau = \tau *$. Note that, $\theta \tau = 1 - \alpha_1 - \alpha_2$

Therefore, the share of total output devoted to finance engineers is same as the share of engineers in total output. This is the efficient outcome.

Proposition 2 If the government maximizes the growth rate then it would allocate its total expenditure among scientists and engineers according to their share in total product.

Wages of specific human capital

Now we can determine wage of engineers (w_h) and wage of scientists (wH)

From equation (2) wage of engineers is

$$w_h = (1 - \alpha_1 - \alpha_2)\, x *^{\alpha_1} y *^{\alpha_2} \qquad ...(19)$$

From equation (16) wage of scientists is

$$w_H = \alpha_1 x *^{\alpha_1 - 1} y *^{\alpha_2} \left(\frac{\delta}{g}\right)^{\frac{1}{1\beta}} \qquad ...(20)$$

The ratio of the wages paid to the engineers and scientists is

$$\frac{w_h}{w_H} = \frac{(1 - \alpha_1 - \alpha_2)\, x*}{\alpha_1 \left(\frac{\delta}{g}\right)^{\frac{1}{1\beta}}} \qquad ...(21)$$

Using equations (11) and (17) we get that $\frac{w_h}{w_H} = 1$. If θ is chosen optimally, ratio of elasticities of output with respect to engineers and scientists is equal to the ratio of share of tax revenue alloted to accumulate them. Therefore, wages paid to them are equal.

$$\text{If } \frac{w_h}{w_H} > 1 \Rightarrow \frac{\theta}{1 - \theta} < \frac{1 - \alpha_1 - \alpha_2}{\alpha_1}$$

In this situation the government is allocating less than optimal share to accumulate engineers. $\frac{\partial g}{\partial \theta} > 0$ if $\frac{\theta}{1 - \theta} < \frac{1 - \alpha_1 - \alpha_2}{\alpha_1}$. So it is optimal for the government to increase θ. This will be true until $\frac{\theta}{1 - \theta} = \frac{1 - \alpha_1 - \alpha_2}{\alpha_1}$. And if $\frac{w_h}{w_H} < 1 \Rightarrow \frac{\theta}{1 - \theta} > \frac{1 - \alpha_1 - \alpha_2}{\alpha_1}$ it will be optimal for the government to reduce θ. So, ultimately in steady state balanced growth equilibrium both types of human capital get equal wages.

Proposition 3 If the government undertakes optimal education policy, then on the steady state BGP scientists and engineers are paid equal wages.

In real life also we see that a doctor and a lecturer in a college, who are specific to their discipline, get almost equal wages if both of them are government employees.

Transitional Dynamics

Let us now analyze the transitional dynamics of the system in the neighbourhood of the balanced growth path by examining the linearized dynamic system around BGP. Using equations (3), (4), (5), (7), (8) I present the dynamic system in terms of the transformed variable x, y, z that describes the equilibrium of the economy.

$$\gamma_x = \frac{\dot{x}}{x} = \frac{\dot{A}}{A} - \frac{\dot{h}}{h} = \delta \left(\frac{1-\theta}{\theta}\right)^{1-\beta} x^{\beta-1} - \theta \tau x^{\alpha_1} y^{\alpha_2} \qquad ...(22)$$

$$\gamma_y = \frac{\dot{y}}{y} = \frac{\dot{K}}{K} - \frac{\dot{h}}{h} = (1-\tau) x^{\alpha_1} y^{\alpha_2 - 1} - \theta \tau x^{\alpha_1} y^{\alpha_2} - \frac{z}{y} \qquad ...(23)$$

$$\gamma_z = \frac{\dot{z}}{z} = \frac{\dot{C}}{C} - \frac{\dot{h}}{h} = (1-\tau) \frac{\alpha_2}{\sigma} x^{\alpha_1} y^{\alpha_2 - 1} - \theta \tau x^{\alpha_1} y^{\alpha_2} \qquad ...(24)$$

The linearized dynamic system around the BGP is as follows:

$$\begin{bmatrix} \gamma_x \\ \gamma_y \\ \gamma_s \end{bmatrix} = \begin{bmatrix} a_{xx} & a_{xy} & a_{xz} \\ a_{yx} & a_{yy} & a_{yz} \\ a_{zx} & a_{zy} & a_{zz} \end{bmatrix} \begin{bmatrix} x - x* \\ y - y* \\ z - z* \end{bmatrix}$$

Where x*, y*, z* are the equilibrium values of x,y,z on balanced growth path and $a_{ij} = \frac{\partial \gamma_i}{\partial j} \forall i, j = x, y, z$

$$a_{xx} = (\beta - 1)\, \delta \frac{1-\beta^{1-\beta}}{\theta} x*^{\beta - 2} - \theta\tau\, \alpha_1\, x*^{\alpha_1 - 1} y*^{\alpha_2} < 0$$

$$a_{xy} = -\alpha_2 \theta \tau x_*^{\alpha_1} y_*^{\alpha_2} < 0$$

$$a_{xz} = 0$$

$$a_{yx} = \alpha (1-\tau) x_*^{\alpha_1 - 1} y_*^{\alpha_2 - 1} - \theta \tau \alpha_2 x_*^{\alpha_1} y_*^{\alpha_2 - 1} + \frac{z_*}{y_*^2}$$

$$a_{yy} = (\alpha_2 - 1)(1 - \tau) x_*^{\alpha_2 - 1} - \theta_\tau$$

$$a_{yz} = \frac{-1}{y_*} < 0$$

$$a_{zx} = \alpha_1 \alpha_2 \frac{(1-\tau)}{\sigma} x_*^{\alpha_1 - 1} y_*^{\alpha_2 - 2} - \theta \tau \alpha_1 x_*^{\alpha_1 - 1} y_*^{\alpha_2 - 2} (1 + y_*)$$

$$a_{zy} = \alpha_2 (\alpha_2 - 1) \frac{(1-\tau)}{\sigma} x_*^{\alpha_1} y_*^{\alpha_2 - 2} - \theta \tau \alpha_2 x_*^{\alpha_1} y_*^{\alpha_2 - 1} < 0$$

$$a_{zz} = 0$$

The above equations can be written as $\gamma = \mathbf{AX}$. On steady-state balanced growth path $\gamma = 0$. There are three eigenvalues/characteristic roots in the system. Sum of the roots is the trace of the matrix A. Let the roots be $\lambda_1, \lambda_2, \lambda_3$. Hence, $\lambda_1 + \lambda_2 + \lambda_3 = a_{xx} + a_{yy}$ (Since $a_{zz} = 0$). Now if the above expression is negative then at least one root is negative, i.e, the system is not unstable. The product of the roots $\lambda_1 \lambda_2 \lambda_3$. is equal to the determinant of the matrix **A**. Now on steady-state balanced growth path $\gamma_z = 0$. From (35) I get that

$$x_*^{\alpha_1} = y_*^{1-\alpha_2} \frac{\rho}{\sigma \left[\frac{1-\tau) \alpha_2}{\sigma} - \theta \tau y \right]} \quad \ldots(25)$$

Since $x_*^{\alpha_1} > 0$, $y_* < \frac{(1-\tau) \alpha_2}{\sigma \theta \tau}$ hence a_{zx} is always positive. Determinant of $\mathbf{A} = -a_{xx} a_{zy} a_{yz} + a_{xy} a_{yz} a_{zx} > 0$ if $a_{zx} > 0$. As a_{zx} is always positive, consequently the determinant is also positive. Hence, the product of the root is positive.

On BGP $\gamma_y = 0$. Using equation (34) I get that

$$z_* = (1 - \tau) x^{\alpha_1} y^{\alpha_2} - \theta \tau x^{\alpha_1} y^{\alpha_2 + 1}$$

Using the above expression we get the condition under which $a_{xx} + a_{yy} < 0$ a_{xx} is always negative. Therefore, if a_{yy} is negative then the trace would be negative.But ayy is negative only if the following condition is satisfied:

$$y_* > \frac{(1-\tau) \alpha_2}{\theta \tau (\alpha_2 + 1)} \quad \ldots(26)$$

If the optimal θ and τ is chosen then the above condition boils down to

$$y_* > \frac{\alpha_2^2}{(1 - \alpha_1 - \alpha_2)(\alpha_2 + 1)}$$

If the above condition is satisfied then the trace is negative and the determinant is positive. Hence, the system is a saddle path stable. The above condition is sufficient but not necessary. This condition implies that the economy is required to have sufficiently high (more than a specified value) capital-engineers ratio to be saddle path stable.

Proposition 4 If the capital engineers ratio is high enough to satisfy the inequality (37) then the system is saddle path stable.

Conclusion

The new endogenous growth theory developed since late 1980s put much importance on human capital accumulation. But it did not give much attention to the possibility of specialization of human capital and the large-scale involvement of the public sector in human capital accumulation. This model considers the fact that human capital may be specific to their uses (manufacturing and R&D) and it shows that there exists an optimal tax rate and expenditure share to be allocated to finance human capital accumulation of different sectors, for which economic growth rate as well as welfare is maximized. Moreover, it also shows that if the sector specific human capital is financed optimally, the said human capital is paid equal wages in the long run.

The model is highly abstract and fails to consider many important features of reality. Individuals are not born equal. Different individuals are endowed with different abilities. The present model does not consider the difference in abilities and difference in preferences of individuals for being engineers or scientists. The problem of occupational choice has not been taken into account. In this model unskilled labour does not play any role in production. The role of the market has also been ignored. It was not considered what happens if R&D and manufacturing sectors are not vertically integrated. The purpose of this paper is to focus on the specific use of the human capital and financing of specific human capital by the government.

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□

Simplicity involves two major processes: eliminating redundant elements and integrating things to make them flow.

– Ken Okuyama

Feature

Staying Competitive in the Globalized Environment: Issues for Indian Management Institutions

Vijaya Bandyopadhyaya & Ashis K. Pani

The inclusion of education on the General Agreement on Trade in Services (GATS) has evoked mixed responses on a global level. This paper delineates the issues, risks and opportunities for Indian management institutions subsequent to GATS. It emphasizes the importance of ensuring uniform world-class quality standards for management graduates to ensure their acceptability in the global marketplace; and suggests the development of a robust quality assurance mechanism for institutions to ensure their sustained competitiveness.

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

Few people in India are aware of the fact that negotiations are going on worldwide that can dramatically transform the higher education sector in our country. It all began with the inclusion of education, particularly higher education, in the General Agreement on Trade in Services (GATS) in 1996. GATS was initiated in 1995 under the World Trade Organisation (WTO) to progressively and systematically promote free trade in services by removing many of its existing barriers. WTO is a powerful organisation with 145 member countries. Initiation of GATS as the first legal trade agreement focusing exclusively on services, as opposed to products, bears testimony to the increased emphasis on trade and the market economy in this era of globalization.

Education is one of the 12 services sectors covered by GATS but its opening up has caused a much greater debate worldwide than any of the other sectors. Supporters of liberalization feel that more trade will mean greater innovation through new providers and delivery modes, greater student access and increased economic gain. However, critics feel that education is essentially a "public good' that if commoditized will mean a threat to the regulatory role of the government and that the quality of education would suffer. At this stage, the questions outnumber the answers about the impact of GATS and trade liberalization. The questions are complex, dealing with technical and legal issues of the agreement itself; education policy issues such as funding, access, accreditation, quality, and intellectual property; the larger political or moral issues for society such as the role and purpose of higher education and the tension between the 'public good' or 'market commodity' approach to education. GATS is new, complex, untested and negotiations are still in progress. It is therefore, difficult to understand or predict its impact (Altbach, 2002; Green, 2004; Hirtt, 2000).

India has up to now made any commitments to open up its education sector. However the increased pressure on it suggests that it is only a matter of time that the impact of GATS will be felt here as well. (Agrawal, 2003; Sirohi, 2003)

This paper attempts to bring out the risks as well as opportunities for India, once it starts opening up its education sector and analyses the impact particularly on management education.

GATS and supply of service

After the 1986-94 Uruguay round of WTO, a new services round began on 1st January 2000. In March 2001, WTO members reached agreements on guidelines for the current negotiations, including the affirmation of the governments right to regulate, expressed in the preamble to GATS; reaffirmation of the principle of flexibility for developing and least-developed countries; and establishment of the request-offer process as the main method of negotiation. The WTO Ministerial Conference held in Doha in December 2002, established a timetable for negotiations. This specified deadlines for initial requests for specific commitments (June 30, 2002); submission of initial offers for specific commitments (Marck 31, 2003); Stock-taking on all GATS-related matters (September 2003, at the Cancun meeting); and a final deadline for negotiations (January 1, 2005). The September 2003 Cancun Ministerial Meeting failed to bring about progress on negotiations.

GATS is based on the principles of most favoured nation (MFN) treatment, national treatment, progressive liberalization and transparency. It is based on a 'positive list' approach i.e. no sector is covered unless it is specifically mentioned in the agreement. Under GATS, trade in service has been defined in terms of the following four modes of delivery:

- Mode 1: Cross-border supply (in which the service crosses the border, such as distance learning);
- Mode 2: Consumption abroad (in which the consumer moves to the supplier's country, as in study abroad);
- Mode 3: Commercial presence (in which the service provider establishes facilities in another country, like branch campuses or arrangements with local institutions); and
- Mode 4: Movement of natural persons (in which people temporarily travel to another country to provide service, as when professors or researchers work abroad). (Agrawal, 2003; Green, 2004)

The commitments so far

'Up to July 2001, 40 countries made commitments for education and 31 commitments were or higher education. While 16 countries made full commitments for cross-border supply and 18 for consumption abroad, only 17 countries made full commitments for commercial presence mode of supply in case of higher education to all WTO members in December 2000' (Agrawal, 2003).

It is not known exactly how many of the 145 WTO members have made initial requests in higher education, because requests are not made public. However, some requests have been leaked, such as United States requests (estimated to all members) to the European Union, Mexico, and Brazil or European Commission's proposals to 29 member states including India. Some members have made their requests public. U.S. made commitments in *adult education* and *other education* and was considering making commitments in *higher education* (www. gatswatch.org/leakannounce.html).

Many governments may want to remove barriers against trade in educational services. However, the few national proposals that have reached WTO mostly underline the need for governments to retain their sovereign right to determine their own domestic educational policy (Knight, 2003; Green, 2004).

The *Australian proposal* recognizes that governments across the globe play a significant role in the financing, delivery and regulation of education, alone or in partnership with private and non-governmental organisations and that governments must retain their sovereign right to determine their own domestic funding and regulatory policies and measures (WTO, 2001 Document S/CSS/W/110;NTEU, 2001).

The *proposal from New Zealand* states that the education sector is vitally important to all countries, given the critical role of education in economic and social development. It claims that reducing barriers to trade in education does not equate to erosion of core public education systems and standards (WTO, 2001 Document S/CSS/W/93).

The *proposal of the United States* recognizes that education to a large extent is a government function and private education and training will continue to supplement, not displace, public education systems (WTO, 2000 Document S/CSS/W/23).

The *Proposal from Japan* brings in the quality concept, stating that it has become extremely important for each country to improve the quality of education and research and respond flexibly to the rapidly changing needs of society.

The trade in Higher Education

Higher education has been internationalized for a very long time and there is significant trade in higher educational services. Certain trends are apparent for quite some time in both developed and developing countries like:

- growing number of private-for-profit entities providing higher education opportunities domestically and internationally;
- use of information and communication technologies for domestic and cross-border delivery of programmes;
- increasing costs and tuition fees at public and private institutions; and
- reduced subsidies compelling public institutions or seek alternate sources of funding.

Extension of GATS to the education sector cannot thus be held responsible for emergence of the above trends. However, it has considerably modified the environment in which higher education establishments must function and broadened the educational market.

The open universities and distance learning universities, having flexibilities in student age range, place and pace of study, had existed as alternates to mainstream universities. Now we have extensions to these in the form of enterprise and virtual universities. Enterprise universities are the final integration of higher training into firm. Academic freedom has become a luxury with public scrutinizing education for its quality, efficiency and enterprise. While distance-learning universities cater to a dispersed student body, virtual universities also outsource their teaching assignments to dispersed faculty, thus ensuring effective cost control (Neave, 2002).

Some countries like Singapore and Malaysia have opened their doors to foreign universities on their own terms. Others, like Argentina, are seeking to understand the impact of foreign providers and to regulate them appropriately. China is slowly opening its doors to overseas academic institutions and programs. The United States is trying to cope with adapting is well-established accrediting system to American colleges and universities offering programmes overseas. Australia is aggressively marketing its educational products overseas. The European Union is moving toward harmonizing its divergent academic system (Ziguras, 2003; NTEU, 2001; NCITE, 2001).

India's present stand

So far India has not made any commitments for trade in education. India has received requests from 17 trading partners since June 30, 2002. In February 2003 documents containing requests by the European Union to 109 countries were leaked to a public interest NGO, Polaris Institute, in Canada. In an open letter to the then Prime Minister of India they alleged that the documents should have been made publicly available and accused the Commerce Ministry of not adhering to the fundamental concepts of transparency and democracy. They opined that access to these documents was crucial to understanding what India had been requested and was likely to offer to analyze possible implications.

India has not made any commitments for trade in education.

India was probably concerned with the inherent imbalance in GATS. The Indian Communication to WTO emphasized that developing countries can meaningfully participate only from 'movement of natural persons' (Mode 4) and not the other three supply modes. Even in Mode 4 there is 'considerable asymmetry' in commitments between different modes of supply and 'minimum level' of commitments. Very few of these commitments extend to independent movement. They are largely linked to commercial presence, favoured by the developed countries, but of very limited use to developing countries. There is also lack of clarity and uniformity, and the personnel categories are either not well defined or differ widely in scope and coverage.

Major entry barriers to labour exist in the form of Economic Needs Tests (ENT), Local Market Tests and Management Needs Tests to ascertain the need for entry and the number allowed to enter. The conditions on which these are based have not been clearly specified and defined, leaving complete discretion in their application. This reduces the predictability and certainty of the commitment. Lack of recognition of qualifications often prevents developing country professionals from practising abroad. Mutual Recognition Agreements (MRAs) are normally limited to developed countries (Green, 2004; Agrawal, 2003; Natarajan, 2003).

Management Institutions in India

The number of institutions offering postgraduate programmes in management has dramatically increased in India over the past decade. There are more than 900 institutions that provide PG programme in management, of which about 760 are approved by the All India Council of Technical Education (AICTE). The unprecedented boom in private sector and entry of translational companies has increased the job prospects of management graduates in highly paying jobs. The interest of the corporate sector and students have translated into increasing interest of the educationists to establish more management institutions.

Global competition means ensuring the quality of graduating students, employability being solely dependent on their ability to meet the challenges in this workplace. The sheer number of institutions will not suffice. Apprehensions are there that it could lead to a drop in quality of MBAs. There are of course some institutions committed to providing the best value for money to students and are working towards changing the general perception of people that government institutions are better. The challenges increase once GATS is implemented and global players enter the market. Approval and accreditation of institutions and courses by globally recognized bodies are important. In India, the national Board of Accreditation (NBA) of AICTE and National Assessment and Accreditation Council (NAAC) of University Grants Commission (UGC) are entrusted with the same.

Global competition means ensuring the quality of graduating students, employability being solely dependent on their ability to meet the challenges in this workplace.

Prospects of foreign students coming to India for study are not too bright. The overall number of foreign students enrolled in Indian universities has been continuously declining. Neither is the prospect of establishing institutions abroad. Central efforts on foreign collaboration are going on but mostly by private run institutes, rather than organized efforts by the government bodies (Sirohi, 2003; Agrawal, 2003).

The perceived threats to Higher Education

Globalization of the education sector, it is felt, will have the power to force countries with quite different academic needs and resources to conform to strictures of the most powerful academic and corporate educational providers and will breed inequality and dependence (People and Planet, 2000). 'Take education out of GATS', an international sign-on statement, was launched on 20th August 2003 to publicly resolve that no education commitments be undertaken in the current GATS round.

The major reasons cited (Neave, 2002; Fouilhoux, 2002; Altbach, 2001; Sinclair, 2003) for opposing the move to open out the education sector are as follows:

1. *Commoditization of education:* Viewing education, traditionally seen as a set of skills and values required for citizenship, as a commodity, will have major implications on our perception about educational institutions, their ownership, transmission of knowledge, and the role of citizenship in society.

2. *Special nature of academics:* Basic research, certain curricular offerings, and other elements of academic work do not lend themselves easily to commercialization. Ensuring that an accounting firm, for example, has free access to international markets or that software is not pirated is not the same as protecting an educational system.

3. *National role of higher education:* Values of the national and social common good must be protected in a globalized environment. Programmes exported off the shelf from industrialized countries are often not relevant for developing countries unless both pedagogy and curricular content take into consideration local conditions, traditions, and requirements.

4. *Undermining the government's role:* The GATS agreement could mark a dramatic step towards a wholly privatized higher education sector. Governments may not have enough policy-marking freedom to ensure that educational needs of citizens can be met on a non-commercial and non-competitive basis.

5. *Business motive:* It is perceived that the overriding motive for ensuring private and global competition in education is the influence of business lobbies and that academic interests may suffer.

6. *New Neo-colonialism:* During the Cold War powerful nations spent lavishly on student exchanges, textbook subsidies, book translations and institution building for ideological and political combination of the world's academic providers who offer a variety of academic programmes, in collaboration with local universities or business enterprises, branch campuses offering degrees and certificates from abroad, IT-based academic degrees, corporate training programmes and

the like. Some providers are involved in training and certification e.g. University of Chicago's Business School in Spain, Pennsylvania's Wharton School initiative in Singapore, and several coalitions of Western universities. There are a much larger number of lower prestige or unknown institutions and companies offering academic programmes of unknown quality and relevance.

7. *Unnecessary legalities:* Around 2 million students are studying outside their home countries. A world market already exists for faculty and researchers. The Internet has greatly expanded international knowledge flow. When internationalization is already taking place at a pace and under conditions suited to the education community, subjecting it to legal strictures of WTO seems unnecessary.

Quality imperatives in higher education: Worldwide issues and concerns

Since 2000, the American Council on Education (ACE) in collaboration with the Council for Higher Education Accreditation (CHEA) has monitored the progress of the General Agreement on Trade in Services (GATS) negotiations on higher education and has participated in the global dialogue on the potential impact of GATS on higher education institutions worldwide. They also have engaged in the ongoing dialogue with the Office of the U.S. Trade Representative (USTR) in an effort to help trade negotiators better understand the complexities of higher education. In September 2002, ACE joined with CHEA, the Association (EUA) to issue a Join Declaration stating their commitment to increasing cross-border education, but expressed serious doubt about the appropriateness of a trade regime to address educational issues. The declaration catalyzed a worldwide discussion among higher education institutions about the implications of GATS. In August 2002, ACE published a background paper that provided general information on GATS, outlined the status of negotiations, and described higher education's concerns about GATS (Green, 2004; Knight, 2002).

Quality assurance of higher education is in some countries regulated by the sector and in others by the government, to a greater or lesser degree. The key point is that authority for quality assurance, regulation, and accreditation for cross-border delivery needs to be examined and guided by stakeholders and bodies related to the education sector and not left in the hands of trade officials or the market (Nyborg 2002).

The European University Association (EUA) and the National Unions of Students in Europe (ESIB) have taken a critical stand on trade in educational services

Authority for quality assurance, regulation, and accreditation for cross-border delivery needs to be examined and guided by stakeholders and bodies related to the education sector not the market.

(Buck and Jonquieres, 2003). The European governments have initiated the Bologna Process to create a European Higher Education Area by 2010, in their Prague Communiqué of May 2001. They supported the idea that higher education should be considered a public good and that it is and will remain a public responsibility. The Bologna Process aims to pull down national barriers while at the same time promoting quality.

Due consideration needs to be taken to:

- maintain and improve the quality of higher education activities in each country,
- protect consumers (learners) against services of low quality,
- ensure international equivalence of degrees and diplomas
- supply information on higher education across borders

An international code for quality assurance, for national information centres and for international information networks was developed at the *Lisbon Convention—The Convention on the Recognition of Qualifications concerning Higher Education in the European Region* by the Council of Europe and UNESCO. These were adopted by national representatives meeting in Lisbon on 11th April 1997. It has since been ratified by 27 countries and signed by 14 more.

The main points of the Lisbon Convention include:

- Holders of qualifications issued in one country shall have adequate access to their assessment in another country.
- Each country shall recognize equivalent qualifications of other countries unless there are substantial differences.

These will ensure:

- access to further higher education studies,
- the use of an academic title,

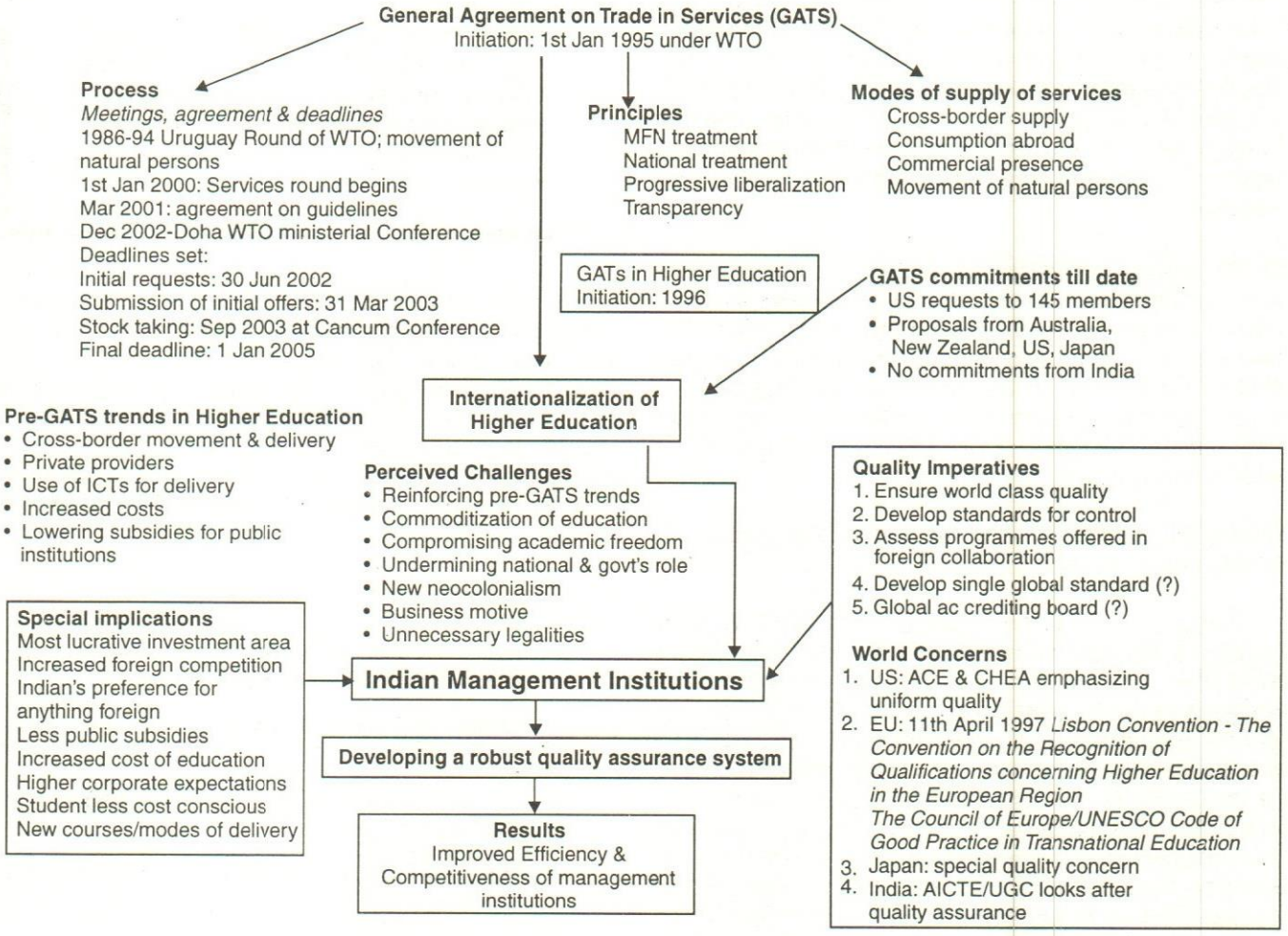

Fig. 1. Staying Competitive in the Globalized Environment: Issues for Indian Management Institutions

- access to the labour market.

- All countries shall appoint a national information centre to provide information on their higher education institutions and offer advice on the recognition of foreign qualifications to students, graduates, employers, higher education institutions and others.

- All countries shall encourage their higher education institutions to issue Diploma Supplement (an instrument developed jointly by the European Commission, the Council of Europe and UNESCO to describe the qualification clearly and by relating it to the system within which it was issued) to their students to facilitate recognition.

The Council of Europe/UNESCO Code of Good Practice in Transnational Education. (UNESCO websites), building on the Lisbon Convention, stated that awarding institutions.

- must ensure academic quality and standards of transnational education programmes at least comparable to their own and those of the receiving country,

- are responsible and fully accountable for quality assurance and control,

- provide clear and transparent information on the qualifications using the Diploma Supplement.

It is important that the GATS negotiations relating to higher education take due account of the Bologna Process and the international conventions and codes of good practice it builds on, in particular the Lisbon Convention.

Among the 41 signatories to the Lisbon Convention were the four leading exporters of educational services: The United States, the United Kingdom, Australia and Canada.

Although under the Lisbon Convention, an effective national quality assessment system in exporting countries is not a formal requirement, importers may stipulate it as a prerequisite for trade.

Multinational providers in transnational education might call for the development of an international accreditation system. However, the task is not easy. National systems differ and there is no internationally agreed quality concept. One may not even wish to introduce overnational regulations, as education is a part of a country's culture identity. Also, not all countries have reached the same stage of development. Commercial and multinational providers of educational services must respect these differences, seeking national recognition in the countries in which they operate, adhering to international conventions and codes of good practice.

Need for a robust Quality Assurance System for Indian management institutions

Even if the quality of education provided by many institutions in our country is in no way inferior, students prefer to study in developed countries or in foreign collaborated institutions in India. Once foreign institutes have their campuses here, the indigenous institutes will face a dearth of students. If foreign providers cream off the management education sector, local institutions will be left with less popular, and profitable, fields of study. These institutions will find it difficult to compete and unable to offer a full range of academic specialties. Further, they will have a dearth of funds and infrastructure to engage in scientific research. Also, the profits that the rich universities may earn in the process can further strengthen their research profile and widen the already existing inequalities in research worldwide.

The positive aspect globalization is that it creates a marketplace where only the best provider of the service would survive. Since students will have ample options to choose from, institutions are compelled to provide the best world-class education to their students to ensure their own survival and growth. This ensures something that all the social, moral and ethical imperatives of education could not. Like corporates, academic institutions also need to continuously innovate, diversify their structure and find new ways of delivering their services more effectively to the students.

Because globalization is inevitable, it is prudent for India to look at its own strengths and device strategies to take advantage of any opportunity that is available. A mix of private and public institutions exists in India. India has the third largest scientific and technical manpower in the world and a large number of educated employable people who can communicate in English.

Students are becoming more quality conscious. They judge institutions by the quality of their courses, infrastructure and modes of delivery. Price consciousness is decreasing. In management studies, apart from regular courses, part-time, evening courses, in-service courses, distance learning, internet courses, twining arrangements and franchising arrangements have become popular. Allowing commercial presence in somewhat better than Indian students going abroad. Strategic alliances or Joint Ventures with foreign institutions are also welcome for financial gains and skill upgradation. Nationally recognized institutions make up for the bulk of the export of educational services in the form of tuition fees paid by foreign students (or by foreign governments). There are suggestions that education-related products like CDs, video cassettes etc. be prepared in India and sent abroad, where it can fetch a large market.

Increased transnational education activity and new legal trade rules require that more attention be given to the question of quality assurance and accreditation of cross-border education programmes and providers. A coherence needs to be developed between international policy approach to quality assurance and accreditation. (Natarajan 2003; Sirohi, 2003; Agrawal, 2003).

In India, the National Board of Accreditation (NBA) of AICTE is entrusted with the task of evolving a procedure for quality assessment in the technical education sector, including management education. The National Assessment and Accreditation Council (NAAC) of UGC, entrusted with the same for universities, takes into account the management courses offered in the universities. They usually provide accreditation at programme level and not for institutions as a whole. They give ratings to institutions, categorizing them as per their quality.

Conclusion

This paper highlighted the special implications of GATS for Indian management institutions, their opportunities and threats and how they can use their strengths to take advantage of the situation, given that GATS is sure to make its effect felt in the coming years. Since GATS is untested, there is a need for in-depth research into the potential effects to fully understand the implications and the proposed deregulation of public education.

Indian management institutions must be well prepared to face the inevitable onslaught of GATS. It was suggested that a robust quality assurance system be developed to ensure world-class quality of these institutions. A mechanism to grade the maturity level of an

institution and a roadmap to achieving higher levels need to be spelt out in certain terms. This calls for further research in this area.

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The first wealth is health.

– Ralph Waldo Emerson

Feature

HR Outsourcing in India – Scenario and Trends

V.N. Srivastava & Kaustab Ghosh

Organizations worldwide have resorted to outsourcing business, business processes and HR. This paper focuses on different aspects and scenario, impacts and trends, problems and prospects, issues and solutions, related to different levels and categories of HR outsourcing.

V.N. Srivastava is faculty at ICFAI Business School, Gurgaon; Kaustab Ghosh is faculty at IILM Institute, Gurgaon.

Being innovative and responsive to changing business environments is requiring greater flexibility. External consultants provide the required training and support to line managers to implement HR practices and policies. HR processes have become intricate and carrying them out efficiently has become a super-specialty. Hiring super-specialized individuals is expensive, and some of them may not be willing to join. The corporate sector embarked on the concept of Business Process Outsourcing (BPO), and has been managing the outsourced processes effectively.

HR outsourcing on a limited scale has been there for a long time, and has in the last decade become very prominent. It started on a low ebb some two decades ago in India, limited to placement services, bulk recruitment of trainees by organizations, contract of select services such as security, canteen, sanitation, catering, transport (passenger and goods), wheel rentals, etc. Outsourcing has become increasingly attractive for many organizations where a company contracts with a vendor that rents its skills, knowledge, technology, service and manpower for an agreed upon price and period to perform functions the clients no longer wants to do (Adler 2003). HR outsourcing has been a growing industry, the majority of which is Business Process Outsourcing (HR - BPO). The HR outsourcing activities started humbly with outsourcing 'payroll processing' of organizations' employees to now outsourcing anything and everything in HR. Business Process Outsourcing has set a key trend to HR outsourcing and the crucial decisions with companies have to be taken as to which HR functions to outsource or which ones not to, or for the entire to be outsourced. The HR department is one among many other departments in an organization. The major concern of the HR department of an organization is to man its department with competent and talented people to give best HR outputs to the organization as a whole. The concerns of HR must, however, match and synchronize with the concerns of the organization's CEO, to optimize returns from investments in HR functionaries. Outsourc-

ing a part of HR functions or the entire HR functions depends much therefore on the strengths, efficiencies and effectiveness of the HR department. If that is so, outsourcing must strike a balance between what functions to be outsourced and what to be retained. It will also depend on the size of the organization, small or large, volume of HR work or initiatives, generalities or the specialities possessed or required. HR outsourcing decisions, therefore, have to be specifically taken to optimize both HR departments and organisations productivity. HR outsourcing has become an industry and in 2000, the industry earned a revenue of $ 21.7 billion, accounting for more than 8% of the total HR spending (Gardner group, 2001).

Business processes have been outsourced and there is an increasing trend for outsourcing the HR functions. The trend during the last decade towards a more 'elastic' company is putting pressure on functional groups. This has been affecting the HR function, too. 'Companies outsource HR functions more than any others and this trend will continue' – says market research major Gartner Inc. recently. The thrust lies particularly in the areas of recruitment, training, performance management and other routine personnel activities like payroll processing and the likes. Many software companies are tending to outsource HR activities in large numbers to expert external consultants. These so-called 'modular' companies can be highly successful if they have reliable vendors and suppliers and, of course, a lot of products! This has paved the way for a large number of HR–BPO companies to cater to the needs of outsourced HR activities. There are even organizations where the HR function has a separate entity to provide consultancy services to external clients, thus establishing itself as a separate profit centre.

There is an increasing trend for outsourcing the HR functions.

As the BPO sector seems to be maturing in India, the player companies are now looking at outsourcing their workforce, both in the core and support functions. All companies are adopting this model of operational HR, whether with the captive BPO units or the ITES companies with third party operations. Infosys's BPO outfit Progeon, which does end-to-end transaction processing, has recently adopted this model with a handful of positions. The model takes care of sudden and temporary requirement of workforce. The best example of a BPO maybe temporary workforce is when there is a holiday festival in the client's country, requiring more hands for processing the extra workload (ET May 24, 2004).

The HR Perspective of BPO Industry

Having taken a 'snap-shot' of different HR issues of the outsourcing corporate, now it is time to turn over to the other side of the coin - i.e. to stay with a $46 billion global market and an annual growth rate of 18-20 per cent, the HR BPO industry is fast waking up to the opportunity by quickly catching up the competencies required and scaling up business activities. The prime focus includes:

- Sourcing the right people from the best talent pool quickly and cost-effectively
- Picking a right mix of the competencies, experiences and behaviours from this talented pool.
- Converting potential applicants to competent employees swiftly, competitively equitably.

Admittedly, HR as taught in management schools at present and as practiced by corporate houses is not in tune with the demands of the HR-BPO industry. Unusual working hours, working days and holidays determined by geographic considerations, pseudo-work identities, learning foreign accents, operating in alien and unstable business environment, altered socio-cultural fabric of work life and the risk associated with working in a nascent industry require a focused HR policy to be developed.

Turmoil in Indian Scenario

Having one of the largest pools of English speaking graduate workforce, the challenge for the industry is not employment but employability. Attrition rate is as high as 50 per cent. Sometimes the prospect of earning a few hundred rupees more could trigger the young employees to switch over to a rival firm and pegging up the cost of employee turnover in terms of loss of skills and the cost of retraining.

Considering the erratic night shifts the employees face and the impatient (even sometimes angry) customers they interact with, they suffer from high stress levels. With an average employee age of 23, the industry has inexperienced youngsters for staff who do not consider it as a serious career option. Mostly they see this job option as a way to make quick money and leave to pursue higher studies.

Companies are often plagued by indiscipline and absenteeism, especially during the weekends. "The best way to deal with this is to show them the hard data and try to create a sense of accountability by showing them

how their conduct has let down an entire team" says Aniruddha Limaya, Vice President HR, at the Gurgaon-based BPO firm, Daksh.

The Rationale behind HR Outsourcing

The rationale behind outsourcing is important. Is it cost economy or more specialized inputs for complex HR solutions? An organization obviously will outsource those HR functions which will involve maybe regular volume, and that can be more cheaper to outsource, or else, the problems require specialist handling and it may be extremely expensive to hire such specialists as such problems do occur but do not recur often. Outsourcing of training programmes to external agencies who have demonstrated specialities in the particular field is a typical example of outsourcing training activities. For organizing a few programmes of that sort of specialization, outsourcing is considered cheapest and best.

A trend is strongly setting in, in which organizations outsource all transactional and administrative services to vendors for whom the outsourced processes are core, leaving HR departments to focus only on HR policy and strategic activities. The core competence of vendors is the main guiding philosophy for outsourcing particular HR activities. Once these activities have been outsourced, the policy and strategic activities can be carried out internally by in-house HR staff, which may consist of highly proficient HR staff, who can make a high level of contributions, internal HR consultants, HR Systems designers and high capability HR executives (Adler 2003).

However, it has been widely experienced that even policy and strategy-level functions can be outsourced. In fact, HR planning level functions where HR policy and strategy aspects are the major components, have been outsourced in many World Bank projects to consultants, professionals and management institutions having specialized competence in evolving such things. Developing and designing also requires specialist handling, and have been outsourced to specialist agencies to get the best plan and systems designed. Such specialists have also been involved in the implementation of such activities to get the best results. In many cases, the best systems were planned but could not be installed effectively and the desired results from such processes could not be achieved. In one of the World Bank consultancies in one of the states in India for example, the World Bank after its review, rated it as an excellent document and plan in any government department of the world, and desired its speedy implementations without fine-tuning or polishing in one of the World Bank project workshop, Bhopal (1996).

Implementation also required specialist handling, and the department decided to implement internally with few HR executives who did not possess the kind of specialization that was required for its effective implementation and getting the best results. Finally, though the best of the systems were developed, the implementation process could hardly go half way and only routine operational HR functions were carried on. An integrated effect could not be had from the plan on which such massive efforts were made by the department. Developing internal HR capabilities of that order may require exposing internal HR executives to a wide variety of problems in a wide variety of organizations, as the same cannot be possible merely by hindsight.

Rationale for outsourcing HR activities therefore cannot merely be by the division or bifurcation of total HR activities into policy and strategic activities and administrative and operational activities, where the latter could be outsourced and the former carried out internally. Outsourcing anything to everything in HR therefore can be possible, and that would depend on the outsourcing needs.

Assessing Outsourcing Needs

Organisations that do outsource must make a proper assessment as to what HR functions or activities to outsource and why? In what way can the internal HR department improve its internal productivity by outsourcing? Organisations have to systematically carry out Outsourcing Needs Assessment (ONA), to be doubly sure of results from outsourcing HR activities, as truly speaking, the HR department is one that manages the most important vital resource.

Organisations can assess outsourcing needs by asking a few questions:

1. What are the organizational mission, goals and strategies to become a leader?
2. What HR functions are routine and voluminous in nature, for which internal HR personnel are rather expensive?
3. What problems are encountered in smoothly carrying out HR activities internally?
4. What are the costs and benefits of outsourcing an activity vis-a-vis carrying it out internally?
5. What are organizations internal deficiencies in carrying out some or more HR functions to manage people effectively and optimize human potentials in the HR delivery systems carrying out line or core organizational activities?

The questions must demonstrate close links between the essential HR activities necessarily required to be carried out either by outsourcing or internally. In fact certain signals may forewarn organizations about the need to outsource a particular HR activity. Some of them may be:

- Inadequate job performance
- Drop in productivity
- High frustration rate among members of the organization
- More need for specialization for certain activities

These are few of the indicators that may signal that it is time to carry out outsourcing HR activities. Some HR activities may require IT knowledge base, which the HR personnel may not be possessing. Such HR activities may be outsourced to a specialized IT vendor. The basic needs assessment for outsourcing must evaluate all HR systems and processes required, whether internal HR functionaries are available, and if yes, do they possess adequate capabilities, and what will be the cost of procurement of such capabilities, and if hired, will they be productively employed, etc. The need has, therefore, to be thoroughly studied to outsource any part of the vital HR job.

Categories and Levels of Outsourcing

Outsourcing is popular in three distinct segments: i) Business Outsourcing, which has more to do with outsourcing businesses worldwide – offshoring, ii) Business Process Outsourcing (Call centres) and iii) HR Outsourcing which is outsourcing various HR activities, such as a) HR consultants, b) administrative service providers and c) technology enablers (Adler 2003).

(a) HR Consultants

HR Consultants provide expertise on issues such as HR policies, HR planning, manpower planning, job redesign, compensation planning, organization development studies, HRD audit, etc. The industry segment includes consulting firms specializing in providing these consultancy services including management institutes. Prominent among these are Hewitt Associates, Boston Consulting, Mercer Human Resource consulting, McKinseys etc.

(b) Administrative Service Providers

Administrative Service Providers handle payroll and benefits processing, recruiting, training, manpower contracting, etc.

(c) Technology enablers

Technology enablers help companies that want to continue managing their back-office processes in-house but need assistance to do so. The companies generally will purchase the needed customized or packaged software. The technology enabler is generally responsible for the implementation, software maintenance, data management, network access and round the clock support and provides the functional HR professionals necessary to use the system. Technology enablers also include traditional IT consultants that have formed partnerships to gain access to HR capabilities (for example, Unisys Corp. with Exult and IBM with Synergy Technologies). IBM's Price Waterhouse Coopers offers a full range of HR services that spans consulting, administrative services and technology. Many outsourcing companies may offer pay rolling and tax processing services for clients but not build systems for clients nor offer consulting services.

The Process of Outsourcing

The process of Outsourcing HR activities involves the following consecutive stages and each stage has its own line of activities to initiate, run and finish the same and move to the next stage down the line.

(i) Project initiation

- Identify the need for outsourcing HR activities in line with the overall business
- Focus on specific HR activity areas that need to be outsourced.
- Make the outsourcing plan on priority and time-bound basis.

(ii) Strategic Consideration

- Determine clearly the outsourcing 'objective' as a set of guiding principles
- Workout 'cost-benefit' analysis and access risks associated with each HR service area being considered for outsourcing
- Establish criteria for selection of service provider and define the types of deals required and how to manage them with speed and confidence to move forward.
- Develop baseline measurements of performance for future comparison.

- Adapt to changing business needs by integrating and successfully managing business and technology innovation.
- Maximize the 'value' of the outsourcing arrangement.

(iii) Vendor Evaluation

- Review external service provider proposals to identify and document any 'gap' between the HR requirements and the vendor service responses.
- Evaluate the four key quality elements to mutual partnership alignment of vision/contract relationship/price and service level and the reliability factor.

(iv) Corporate Communication

- Deliver the right message to the right audience at the appropriate time consistently across the entire organization.
- Reduce fear, gain acceptance of the outsourcing plan and share expectations.
- Minimize and prevent unplanned turnover and the associated loss of the critical business knowledge and skills of human capital.
- Build trust and commitment among employees to facilitate smooth transition during the outsourcing phase that prepares the ground for finalizing blueprint solutions and plans for implementation.

(v) Contract Management

- Define key organizational role and new business processes to support the redesigned organization and customize a corporate governance model to manage the same.
- Establish and negotiate contracts on business principles of flexibility and cooperative decision-making that makes way for realistic expectations of achieving cost service benefits.
- Manage the effective transfer of knowledge and skills of best practices to the external service provider through overall contract assessment assistance.
- Make action plans for objective assessment of the outsourcing relationship on an ongoing basis.

The HR Imperatives - Problems and issues

The main task of the HR department in the outsourcing exercise focuses primarily upon the selection of the best and least costly outside contractors for HR products and services, making sure these products and services are being used properly and finally evaluating and adapting these products and services in the most effective and efficient manner. As the requirement and situation varies from case to case, sometimes the corporate may like to outsource only a portion of specific HR sub-functions instead of dealing out the whole. For example, in the area of recruitment the requirements vary like - keeping direct hire process in-house, while shifting over of the contingent workforce to the BPO-HR vendor.

Submitting temporary or direct hire requests to the vendor only on an "as needed" basis, e.g. when internal staff is overloaded or their efforts have proved unsuccessful. Utilizing the vendor completely to support or manage outreached programmes such as campus recruiting, job fairs and like. To correctly address and remedy the above issues, the HR department of the company needs to concentrate on the following:

(i) Specific Job Training

Employees along with their supervisors should devise a continual learning plan. The module should include an evaluation of skills that will be high in demand in the industry in the near future, along with the steps to take along the way. It must ascertain whether to go for traditional class room participation or online learning

(ii) Profiling stable workforce

Attempts to make gradual hikes in recruitment of middle aged part-timers and less of fresh collegiates, say e.g. mothers whose children are a little grown up and who need a second income could join as part time employees. The people who like serving others with a smile and are of the caring sorts with the right temperament need to be recruited.

(iii) Stress Management

The employees should be trained in reducing stress both at work and personal level. Keeping the hordes of restless youngsters happy at work becomes perhaps the biggest challenge for HR executives of BPO firms. "An informal, enabling and fun work culture is a must at call centres", explains Anairuddha Limaye, VP – HR, Daksh.

(iv) Career Development

The qualified and the skilled manpower as the back-

bone of the industry should take this profession as a viable career option and not as means to earn pocket money or gain experience to fly off. The HR manager or the immediate boss should sit with the employee from time to time to discuss and track out his career options within the organization. Keeping a close watch on his performance, he needs to be taken out of call handling jobs after a point and equipped with vertical skills to be placed at a higher position that widens his career mobility.

Attrition is high when the industry is in a growth phase and flattens as the growth slows down. The study prevails that this high level of attrition will stabilize once the new industry matures. As the opportunities reduce, employees will stick to their jobs and opt for progression within the organization. Competition has been knocking and the countdown has begun for the result of the final encounter. Be it the outsourcing corporate or the HR service provider BPO company, the HR function is omnipresent in its own form, capacity, significance and variability. HR outsourcing as a fallout of internationalization of business is here to stay, with India being no exception to the same. However the success depends on how well both the parties can collectively and assertively integrate their business ties not as 'giver' and 'taker' of service but as business 'partners' in the true sense of the term.

Conclusion

HR outsourcing is a highly popular emerging concept in delivering HR services and discharging HR functions. It is one of the most important ways an organization uses to implement HR practices and policies. It helps organizations in carrying out intricate HR processes with a touch of super-specialty. Organizations today have to invariably look for outsourcing to hire on rent HR outsourcing organizations skills, knowledge, technology, service and manpower. The companies have to take critical decisions as to which HR functions to outsource or which ones not to, or for the entire be outsourced.

The rationale behind outsourcing is important to consider. Is it cost economy or more specialized inputs for complex HR solutions? An organization obviously should outsource only those HR functions which will involve maybe regular volume, and that can be more cheaper to outsource, or else, the problems require specialist handling which may be extremely expensive to hire. The core competence of vendors must be the main guiding philosophy for outsourcing particular HR activities.

In a nutshell, organizations must assess outsourcing needs. This might invariably involve asking a few questions such as:

- What HR functions or activities to outsource and why?
- What way can the internal HR department improve its internal productivity by outsourcing?

The various minute processes of outsourcing and consecutive stages such as project initiation, strategic considerations, vendor evaluation, corporate communication, contract management, etc. must be carefully carried out. HR department members must redefine their various roles to have clearly specified policy issues etc. in the light of various HR imperatives - problems and issues, to maintain a proper focus on the selection of the best and least costly outside contractors for HR products and services. To correctly address and remedy the above issues, the HR department of the company needs to concentrate on specific job training aspects, profiling of stable work force, stress management, career development, etc.

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The very process of writng a list clarifies and focuses the mind.

– Anthony Bourdain

Feature

Organisational Learning: A Review

Bijaya Mishra, Rajen Gupta & Amulya Khurana

In this paper an attempt has been made to identify various constructs related to organisation learning. On the basis of review of literature five attributes have been found to be vital for organisational learning: Individual learning, knowledge creation, organisation culture, organisation structure and process and adaptability to change. These factors help an organisation to develop a learning capability which in turn helps it to withstand the environmental pressures. The aim of this paper is to understand the learning mechanisms through which an organisation suffices the adaptability requirements and stands out as a learning organisation.

Bijaya Mishra is a doctoral student at IIT, Delhi; Rajen Gupta is Professor at the Management Development Institute, Gurgaon; and Amulya Khurana is associate professor, IIT, Delhi.

Organisations today are caught in a vortex of over-changing external milieu, fast-changing technological obsolescence coupled with human obsolescence. One mechanism which has clearly emerged as a panacea to organisation is learning, which is continuous, pervasive, integrative and prescriptive. It should be the primary domain of the corporate armory and be imbibed in the corporate culture. The fundamental changes which affect organisations, mandate the application of learning principles towards the value creation logic by the firm. There has been a shift in the scheme of things for organisations, as most of today's products/services are intangibles and are the creation and innovation of human/intellectual capital.

Majority of today's organisations fall in the learning grid, since they have to create new products not only to off-shore competition, but also to "kill" their own products in the marketplace, which has come to be known as 'Cannibalisation'. Companies like Microsoft and 3M practice this concept in order to stay ahead of others. The challenge is not only of learning, but to gain the ability to learn faster than competitors. Much of the value of a firm as depicted by the market capitalisation and share prices of software and knowledge industries is garnered by knowledge creation, which in turn comes through learning. Learning occurs when organisational members learn individually as well as collectively, and when that learning gets embedded in the systems and processes.

Though the concept of organisational learning existed even earlier, it gained currency with the work of Argyris & Schon (1978). Subsequently, Senge's (1990) 'learning organisation', 'learning company' model by Pedler, Burgoyne & Boydell (1991) and Nonaka's (1991) 'Knowledge creating company' contributed to the popularity of the concept.

The concept today has varied notions and has been defined differently by different authors. The aim of this paper is to review the existing literature and highlight and emphasize on the emerging themes. An examination of

the existing literature shows that the review reels around five main attributes viz., individual learning, knowledge creation, organisational culture, structure and process, and adaptability to change. This paper focuses on these attributes which are the principal drivers, since adaptability to the change process demands new ways of delivering things which in turn requires new skills and knowledge, which have to be acquired through individual learning that requires a change in the existing organisational culture and structure. The relationship between the attributes is so intricate that together they create the 'learning organisation' which has the ability to sustain turbulence and survive in a knowledge economy. These five attributes are discussed in depth taking inputs from the existing literature.

Individual learning

An organisation is an aggregation of individuals working for it. Organisational learning is contingent upon the learning of its members. Individual learning has a profound influence on organisational learning and it ultimately modifies the learning aspect of the company. According to (Argryis & Schon; 1978a), individuals are agents of organisational learning and organisational learning takes place when individuals face a problematic situation and probe into it on the behalf of the organisation. They encounter such a situation by processing their thoughts and modifying their activities, such that the output and expectations fall in line, thereby rewriting existing organisational theory.

Organisational learning occurs when interaction among its members takes place based on their education and experience (Kolb, 1984). (Argyris & Schon, 1996) once again assume individuals as the only proper subjects of learning, and the individuals who inhabit organisations, bear the responsibility for contributing to performance of organisational learning. Simon (1991) strengthened this view further by claiming that 'all learning takes place inside individual human heads' and organisations learn either through learning of their members or by taking in new members with new knowledge. Smith (1999) writes 'a company which is governed by the philosophy of fostering a climate of learning for all its employees has to be known as a learning organisation'. Tajima (2001) was further of the view that a learning organisation evolves as a result of the learning of all its employees, not just key individuals or people with specific needs. The making of a learning organisation prevents the hardening of mindsets of its employees and managers. A learning organisation is a place where people learn continuously together and the rate at which organisations learn helps them to gain a competitive advantage (Senge; 1990). Senge's view of learning organisation also encompasses the learning of all its members.

Organisational learning occurs when interaction among its members takes place based on their education and experience.

The above mentioned views by different authors gives an impression that individual learning is sine quanon for organisational learning. Previous literature on organisational learning put a great deal of emphasis on individual learning. Organisational learning may occur independently of any specific individual but not independent of all individuals (Kim, 1993).

This opinion is contested by Marsick & Watkins, 2003a. They said 'learning at the organisational level is not the sum of many people learning'. Though learning by individuals is necessary, it is not sufficient for organisations to learn and change. The enhancement of the overall organisational capacity is dependent upon the individual member's capacity, as long as the organisation is receptive to their efforts to use their learning. This notion was further strengthened by Field (1997). His work focuses on the negative aspect of learning that an individual might inculcate for his own personal growth, which might not actually contribute to organisational learning.

Though consensus is lacking over the controversy of whether individual learning contributes to organisational learning, some theorists skillfully avoid such a controversy and suggest that individual learning and organisational learning are two separate things. Argyrix and Schon, (1978) go a step further and insist that organisational learning must take account of the interplay between the actions and interactions of individuals and the actions and interactions of higher level of organisational entities such as departments, divisions or groups of managers. Unless this criterion is taken into consideration, useful knowledge cannot be created.

Therefore the literature suggests learning to be an integral part of organisational learning and one leads to the other and vice versa.

Knowledge Creation

Most organisations today survive and respond in the ruthless marketplace by creation and acquisition of new knowledge. Customer's preferences change over

time and keeping abreast with the needs of the customer necessitates new ways of delivering things. Hence acquiring knowledge is not only critical for individuals but also crucial for organisations. Long-term survival and the competitive success of organisations is determined by the manner in which they attempt to learn, create, transfer, codify and utilize knowledge. Any change in the state of knowledge gives rise to organisational learning, (Lyles; 1988) and it involves knowledge acquisition, dissemination, refinement, creation and implementation.

An organisation which is efficient in creating, acquiring, and transferring knowledge and at modifying its behaviour to reflect new knowledge and insights, is a learning organisation (Garvin; 1993). Most companies focus on these knowledge management activities by creating, identifying and collecting best practices or learnings from their external and internal environments. Shifting markets, proliferation of technologies, growing number of competitors, product life cycle reduced to overnight, compel successful organisations to consistently create new knowledge, disseminate it throughout the organisation and embody it is development of new technology and products (Nonaka; 1991). These activities are practiced in a knowledge-creating company, which is always engrossed in innovation. The essence of innovation is to recreate the world according to a particular vision or idea. Knowledge invention is a way of behaving, a way of being, in which every one is a knowledge worker. Nonaka is his work cites examples of Japanese companies on the ways of creating new knowledge.

How is this knowledge created? Any form of new knowledge emerges only from individuals. When this personal knowledge is transferred into organisational knowledge, it becomes a valuable asset for the company. Making this personal knowledge available to others in the organisation is the central activity of the knowledge-creating company (Nonaka; 1991b). There are two types of knowledge i.e., tacit and explicit. Tacit knowledge is highly personal and is not easily expressible. It consists partly of technical skills and partly of cognitive dimensions attached to it. On the other hand, explicit knowledge is formal and systematic and it can be communicated and shared with others. According to Nonaka there are four basic patterns for creating knowledge in organisations viz., these are socialization, articulation, combination, and internalization. These patterns exist in dynamic interaction in a knowledge-creating company. Articulation (converting tacit knowledge to explicit knowledge) and internalization (using explicit knowledge to extend one's own tacit knowledge base) are critical patterns in the knowledge-creation process.

The process of converting tacit knowledge into explicit knowledge is through metaphor, analogy and finally crystallizing the concepts into a model. Knowledge creation requires process redesigning and redefining of managerial roles and responsibilities. The basic principle followed in Japanese companies for organisation design is redundancy. Redundancy can be achieved through strategic rotation, free access to company information and redefining role of managers at different levels. Knowledge creation can happen through redundancy, and that is what Nonaka has powerfully articulated in his paper.

Nonaka and Konno (1998) stressed the need for 'ba' ("place") in knowledge creation. 'Ba' is a shared space which acts as a foundation for knowledge creation. This space can be physical (like an office) or virtual (as in e/mail or tele-conferencing) or mental (shared ideas or expressions) or a combination of all. As "ba" is grounded in sharing, it helps in uniting teams, informal groups and even organisations. Knowledge can be acquired and generated by investing in research and development, listening to customers, learning from competitors, tapping an organisation's tacit knowledge and employee training (Shukla, 1995). The paper further highlights each aspect elaborately, taking foreign examples.

An organisation's tacit knowledge can be made explicit by creating learning forums, organizing conferences, worldwide interaction among company members, redesigning the work and so on. As per the author, India has latent advantages in terms of variety of Indian markets, pool of professionally competent human resources, multi-cultural and multi-lingual society which helps in adjusting to alien cultures, and the second largest English speaking population. Besides these, some of the factors which are needed for companies to compete in a global market are identifying the knowledge creating sources, finding management strategies for acquiring this knowledge, organizing themselves for the effective utilizing of this knowledge, acquiring and updating knowledge-based capabilities, creating structures to facilitate learning.

An organisation's tacit knowledge can be made explicit by creating learning forums, organizing conferences, worldwide interaction among company members, redesigning the work.

Learning can take place when knowledge spreads quickly and efficiently throughout the organisation. Ac-

cording to Garvin (1993), knowledge transfer occurs through a variety of mechanisms like written, oral and visual reports, site visits and tours, personnel rotation programmes, education and training programmes, and standardization programmes. Out of these, reports and tours constitute, by far, the most popular media. But in spite of their popularity these methods help in transferring knowledge only in a passive form, as experiencing them personally is quite difficult. For this reason, a personnel rotation programme is a powerful method of knowledge transfer. Transferring of knowledge may occur from division to division, from department to department and it may involve senior, middle or front-level managers. Other knowledge transfer tools are education and training programmes conducted by organisations. Organisational knowledge is stored partly in the individual's memory and partly in organisational reports, data, record, rules, regulations etc. (Weick and Roberts; 1993).

In a learning organisation, knowledge is not only created and transferred, but knowledge is highly and visibly valued. Leonard-Barton, (1992) has described how knowledge accrual takes place in Chaparrel Steel. In a learning laboratory like this, knowledge creation and control is visible in highly innovative physical systems. Knowledge accrual occurs throughout all levels in a homogeneous way. Knowledge (whether in terms of its success or failure) is shared by every one in a learning laboratory. Thus knowledge constitutes the basic ingredient for building a learning organisation where learning becomes the way of working – thinking, planning, strategizing, and executing; adding value and implementing in organisational functioning. As quoted by (Smith, 1999), a learning organisation needs to be designed and developed in a specific and very practical fashion such that there occurs a very rapid and continuous exchange between explicit and tacit knowledge, resulting in little opportunity for mindsets to become frozen.

Organisational culture

There has been a strong emphasis on organisational culture in the organisational learning literature. Culture is like a binding bridge which holds an organisation in tact. 'Culture serves as a sense making mechanism that guides and shapes the values, behaviours, and attitudes of employees' (O'Reilly & Chatman, 1996). Organisational learning culture acts as a strong catalyst that fosters or inhibits the application of knowledge of employees in organisational activities (Bhatt; 2000). A learning culture also explains often unexamined assumptions about how things are done, as well as the norms and values that guide employees' behaviour (Gephart, Marsick, Buren & Sprio; 1996). The culture of a learning organisation supports and rewards learning and innovation, promotes enquiry, dialogue, risk taking and experimentation. Simultaneously it allows for sharing of mistakes and values as stated by the author. Besides this, there exists a free and open system for communicating information and knowledge in a learning organisation. According to Marquardt, (1996) a learning organisation consists of the four key dimensions of strategy, vision, structure and culture. Its stresses the importance of continuous learning – at all levels, functions and divisions throughout the firm. Lam & Pang, (2003) carried out a school reform study and found that transformational leadership, positive school culture and supportive structure are most critical in promoting organisational change and have immense influence on the organisational learning process and outcomes.

Culture is like a binding bridge which holds an organisation in tact.

Goh (2001) in his study tried to find out five attributes of a learning organisation. These attributes are clarity of mission and purpose, shared leadership and involvement, experimentation, transfer of knowledge and teamwork and cooperation. In a learning organisation, managers act as coaches and facilitators fostering a sense of shared understanding of the organisational mission and purpose.

Jones (1996) described the traditional cultures as anti-learning, which undermine the ability of the organisation to gain a competitive advantage. He highlighted the importance of team culture for effective utilization of new knowledge and skills.

The importance of teamwork for learning has also been mentioned by Stata (1989). In his company, Stata as Chairman tried to capture the essence of team work. Working as small teams helps in introducing knowledge and modifying behaviour, which helps the organisation to learn. White (1994) highlights the importance of group learning by stating that 'the greatest learning takes place collaboratively' i.e., within an organisation, the fastest, most reliable and useful knowledge and information comes from the exceptional clarity, energy and wisdom emerging out of collaborative exploration and participation. She further describes the usefulness of computer technology in disseminating knowledge across different culture.

The importance of dialogue for organisational learning is wonderfully described by Schein: 'If any new or-

ganisational responses are needed that involve changes in cultural assumptions or learning across sub-cultural boundaries, dialogues must be viewed as an essential component of such learning' (Schein; 1993). For organisational learning to occur, dialogue is necessary not only at the executive levels but also across all levels. Barrett (1995) talks a new kind of learning i.e., appreciative learning, where the learning culture involves not problem solving i.e., not just adapting and responding to problem, but going beyond it—to innovative thinking.

Dymock's study (2003) describes learning culture as the willingness for all parties in an organisation to acknowledge the power relations in the organisation, particularly when the organisation functions in a competitive environment. For this, establishment of sufficient trust between management and staff is required.

Some researchers also stressed the importance of leadership in building a learning organisation, like Schein, (1992) and Senge, (1990).

An enabling culture is an important pre-requisite for learning to happen in organisational settings. Most of the papers reviewed have articulated this view about culture.

Structure and Processes

Structure and processes are the basic facilitators which help in building a learning organisation. Marquardt, (1996) defines the organisation structure of a learning organisation as 'seamless and streamlined structure' which tries to minimize the distance between people and processes, while maximizing contact, information flow, and collaboration among individuals and teams.

Structure and processes are the basic facilitators which help in building a learning organisation.

Rastogi, (1995) suggested some guidelines for building structures and devices supporting learning in organisations. Some of these are: cross-disciplinary teamwork, removal of internal barriers through cross-functional integration, redefining the firm's outer boundaries so that new ideas and insights can be taken into account fro suppliers, customers, and competitors and so on. Other methods like training and development of personnel, benchmarking of best practices, focusing on practices like Total Quality Management (TQM) and Just in Time (JIT) need to be a part of the learning process.

Garvin (1993) coined the term 'learning forums' which are programmes designed with explicit learning goals in view. These programmes are of different forms like strategic reviews, systems-audits, internal benchmarking reports, study missions to leading world class organisations, and symposiums, etc. These forums help learning to happen at a faster pace by requiring employees to confront new ideas, competing perspectives, hidden issues and their implications.

The roles played by the people at three levels, i.e., organisation, team and individual level have significant bearing on the organisational learning process as described by Khan, (1999). The strategic objectives of the organisation are achieved by adopting 'enabling structure', which enhances team learning. This a more flexible structure and tries to avoid hierarchy.

Ramnarayan and Bhatnagar (1993) report that teamwork, introduction of processes like quality circles, and employee surveys foster learning in organisations. Some factors like excessive bureaucracy, centralized methods of working, too many hierarchies and too many functional specialists working in organisations, which lead to functional myopia, hinder learning in organisations. Leonard-Barton (1992) studied Chaparrel steel's structure and found that in this learning laboratory, hierarchical boundaries are minimal, and work is structured with the objective of disseminating knowledge. Multifunctional experience is encouraged for the smooth transferring of information. There is no separate research and development department from production.

Based on his empirical study, Goh (2001) proposed a learning organisation framework. This shows the structure of a learning organisation as non-hierarchical and non-formalized, i.e., employees are not closely monitored and do not have excessive controls in their job environment. Marsick and Watkins (1999) asserted that 'learning organisation has always been oriented towards growing and developing an organisation, not sinking or even destroying the knowledge capital of the organisation'. However, it does not mean that an organisation which has experienced a reduction in workforce can not be a learning organisation. They further cited examples of different organisations which have worked towards becoming a learning one, in spite of having their workforce reduced.

The structure of a learning organisation has to be designed in such a manner that it can capture and share learning as stated by Gephart, (1996). Besides, it has to overcome internal divisions and rigidities, to facilitate work and learning across external boundaries in order to capture and share learning. Lam and Pang's (2003)

study on school reform suggests the school structure needs to be a flexible one like team working, flexible scheduling and more collective decision-making in order to endorse learning.

The above studies indicate that the structure of an organisation should be flexible, non-formalised, non-hierarchical and a team-based one, so that information can be shared and learning can be captured.

Adaptability to Change

Needless to say the above mentioned factors necessitate learning, but it is the change coping capability that instigates an organisation to recreate itself as a learning organisation. More like the 'survival of the fittest' in the kingdom, in the world of business the basic criterion for organisations to survive is by coping with turbulent business environments. As rightly highlighted by Smith, (1999c), 'learning organisation is a useful organisational metaphor for successfully dealing with change'.

Mankidy (1996) defines learning organisations as 'those, which avoid becoming extinct'. These organisations respond to changes by making successful modifications in their every day functioning. Thus change coping criterion stimulates these organisations to transform themselves into learning organisations. Mankidy described three requisites for learning to happen in an organisation, the presence of which will help an organisation to become a learning one. The requisites are sensitivity to environment, analysis of changes and earlier experience, and planning the strategies to deal with changes. Sensitivity to the environment is the most vital component because it helps in anticipating some of the changes based on a comprehensive perspective of events. Analysis of the changes means analyzing it and identifying the positive and negative aspects of changes so that strategies can be developed. Planning strategies to deal with the changes involves taking advantages of changes, which are conducive to organisations, and avoidance of negative impact of undesirable changes. The author has cited examples of different learning organisations and their action strategies. The strategies of these organisations differ from each other.

Johnnie (1996) maintains that organisations learn because they have cognitive systems. The survival of the organisations depends on how they explore and master their environments. The society in which learning organisations operate is made up of a multiplicity of variables and is a dynamic force of social change. These changes are governed by political, economic, technological and socio-cultural factors. Any change in these factors affect an organisation's functioning. As the environment of the learning organisation is often exposed to constant changes, learning is required on the part of this organisation to wipe out outdated thinking and start anew. In order to face negative environmental changes, learning organisations should be involved in experimentation, expose themselves to a variety of stimuli and learn to identify them using their metasystems, redesign their environment and try to maintain dynamic equilibrium by a two-party governance of their members.

Environmental impact like new regulation, new competition, market downturns, new technology, customer dissatisfaction or new demands, new vision or some other change directly affect organisational functioning and trigger learning (Marsick and Watkins; 2003).

McGill, Slocum, & Lei (1992) have stated that 'The more a company penetrates global markets, the more its success depends on the ability to quickly and effectively respond to myriad of changes'. As it is evident from this statement, to compete in global markets, organisations need to respond in faster ways. Thus there is a greater need for designing organisations that can learn. The authors have described different styles of learning to cope with change, which are adaptive and generative learning. Adaptive learners show a stimulus-response behaviour while reacting to changes, whereas generative learner's exhibit precautionary type of learning while interacting with the environment. Generative learning helps organisations to transform themselves thereby improving their effectiveness. Leadership ability is another criterion for building a learning organisation, which encompasses factors like empathy, systemic thinking, creativity and a sense of efficacy.

Organisational learning assumes importance in the context of requiring new skills to face profound changes in the Indian corporate environment as described by Ramnarayan and Bhatnagar, (1993). Factors like rethinking within the top management, change in leadership, and changes in business environment are found to act a as major impetus for change necessitating greater learning. To cope with change, the key managers need to perform three important roles: Developing change agenda for the organisation, fostering learning culture and creating structures and mechanisms for better integration. Thus a challenging change programme establishes the need for learning and energizes the organisational learning process.

Schein (1993) explained how organisations, in order to keep up with the rapidly shifting environment, need to change faster, so that a learning organisation could be

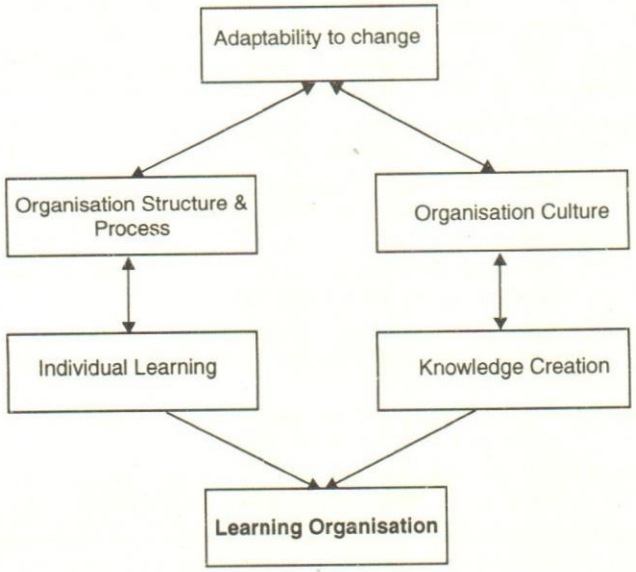

Fig. 1. A conceptual model of learning organisation.

developed. The rapidly changing environment is labeled as the 'scary green room'. So to enter into the green room, leaders need to speed up the learning process in organisations. First they should start with an analysis of themselves and their learning need. Then they need to consider anxieties, defenses and cultural assumptions which stand in their way and think how to create a psychologically safe network for people so that they can learn. In this context a parallel learning system should be created so that people can cope with anxieties, while meeting challenges arising out of changes.

The pressures to change have been really unforgiving, urging organisations to reinvent and re-orient their age-old established systems and practices and fine-tune themselves to fit the new order. Fortunately and incidentally organisations get into the learning bandwagon either knowingly or unknowingly through inculcating new knowledge and skills in the employees, who transfer the new-found knowledge through the already described process of 'ba'. Once this becomes organisational knowledge, the structure and processes are altered to shape the new learning with the help of the organisation's nurturing culture. Then organisational learning becomes common place occurrence.

The pressures to change have been urging organisations to reinvent and re-orient their age-old established systems and practices and fine-tune themselves to fit the new order.

The five attributes of organisational learning have been summarised in table 1:

Table 1: Process of Organisational Learning

Focus	Views	Learning guidelines
Individual learning	"Individuals are agents of organisational learning" (Argyris & Schon, 1978)	Education & experience, probing problematic situation, continuous learning of all members.
Knowledge Creation	"Learning organisation is efficient in creating, acquiring and transferring knowledge and modifying its behaviour to reflect new knowledge" (Garvin, 1993)	Conversion of tacit to explicit knowledge, sharing of knowledge between individual and organisation, knowledge transfer through personnel rotation, valuing knowledge .
Organisational Culture	"Organisational Learning culture acts as a strong catalyst that fosters or inhibits the application of knowledge of employees in organisational activities" (Bhatt, 2000).	Supporting and rewarding innovation, sharing of mistakes, transformational leadership, dialogue making.
Structure and Process	"Structure and Processes are the basic facilitators which help in building a learning organisation", (Marquardt, 1996).	Cross-functional team work, benchmarking of best practices, and avoidance of too many hierarchies.
Adaptability to Change	"Learning Organisation is a useful organisational metaphor for successfully dealing with change" (Smith, 1999).	Sensitivity to environment, redesigning the environment, role of leader to build safety network.

Basing on the review of the literature, a conceptual model of learning organisation has been proposed in Fig. 1.

Conclusion

Several authors have espoused various perspectives of organisation learning. Five attributes namely individual learning, knowledge creation, organisational culture, organisational structure and process, and adaptability to change have been identified by reviewing the existing literature. Notably individual learning lies at the heart of the knowledge creation process which alters the existing organisational structure, process and the prevailing culture in order to dove-tail with the objective of creating learning organisation. Review of literature indicates that these five attributes stimulate organisations to move towards a learning mode.

The concept of organisational learning is not new. A lot of writing has gone into the management literature on organisational learning. It is seen as something

which organisations should constantly aim for. Though this concept appears to be a one shop-stop for all organisational ills, what is needed is the translation of this powerful theoretical paradigm into a practizing reality. And this requires valid measurement as rightly pointed out by Garvin, (1993). Although many definitions have attempted to capture the essence or meaning of learning organisation, it still remains elusive to move the theory to reality without effective 'measurement tools'.

In terms of the agenda on research on organisational learning, some of these issues require further investigation:

- There is a need to develop valid measures for learning organisations.
- To study organisation learning, a cumulative, integrated and holistic approach is needed rather than a disjointed one.
- The methodology should adopt various types of research like case studies, thorough empiricism. While individual case studies and anecdotes are important to understand learning, additional value can be derived from empirical assessment spanning a large number of organisations.
- Another important area for further research is to understand how features of organisational culture and structure facilitate learning capability and whether these features lead to superior organisational outcomes.

Based on review of literature a model has been proposed incorporating the five attributes. However, the model needs to be empirically tested.

Finally in order to make learning happen in organisations, every smart CEO and every smart manager should understand and appreciate this powerful concept and implement it to falsify the commonly held notion that a "Learning Organisation" is a myth.

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Feature

Impact of Leadership Styles on Work Behaviour of Subordinates

K.R. Chaturvedi

Leaders' role, responsibility, function and ways of interacting with subordinates affects work behaviour either positively or negatively in different layers of organisational hierarchy. To examine these, three leadership styles, namely, authoritarian (F), Nurturant-task (NT) and Participative (P) were taken, and data was collected from two units of the Indian Air Force (IAF). Results reveal that airmen and officers were highly committed, more satisfied, showed more concern for work and were unwilling to leave the organisation under the P leader.

K.R. Chaturvedi is a senior lecturer at Apeejay Institute of Technology, Greater Noida

The topic of leadership has been discussed more than any other aspect in the field of organisational behaviour. There are many ways of looking at leadership. Leadership is a process whereby a person exerts social, ethical and psychological influence over the members of a group. A leader, then, is a person with power over others who exercises this power for the purpose of influencing their behaviour at work (Skaret & Bruning, 1986). This influence of leaders will have a certain impact on work behaviour of subordinates (Khuntia & Suar, 2003). Much of this will depend upon the style of leadership, how one is interacting, controlling, supervising, monitoring, coaching, caring and involving subordinates in decision making.

Leaders exhibit different styles with subordinates in different situations. However, researchers have advocated effectiveness of a particular style in a particular situation, culture or context. Sinha (1980) argues that Nurturant-Task (NT) leaders who care for their subordinates, take personal interest in their career growth and help them to grow and gain maturity (Sinha & Gupta, 2002) are more effective in the Indian scene. He further states that NT has an overlap with Authoritarian (F) leaders who are rigid, discipline minded, power-oriented and decision-makers on one side, and Participative (P) leaders who are consultative, mix up and take joint decisions on the other side. This study examines how these leadership styles affect the work behaviour of subordinates considering the subordinates' attitude towards: (a) organisational commitment (b) job satisfaction (c) challenging task (d) work centrality (e) intention to quit (f) target realisation, and (g) hard work.

Employer-employee relationship: seven variables

(i) Organisational Commitment

Porter, Steers, Mowday and Boulian (1974) and others defined organisational commitment as the rela-

tive strength of an individual's identification with and involvement in a particular organisation. Organisational commitment includes (a) employees' strength of attachment and identification with the organisation (Morrow, 1983; Zahra, 1984) (b) a strong belief in and acceptance of the organisational goals and values, (c) willingness to give energy and loyalty to the organisation, and (d) a strong desire to remain in the organisation or unwillingness to leave the organisation (Cook & Wall, 1980).

Organisational commitment may be classified either as an attitudinal or a behavioural concept. Attitudinal commitment refers to the process by which employees come to identify with the values of the organisation and are desirous of maintaining membership. In contrast, behavioural commitment refers to the process by which an employee's past behaviour serves to bind him or her with an organisation. Thus, organisationai commitment refers to the nature of the relationship of the members to the system as a whole. Two general factors that influence the strength of a person's attachment to the organisation are - the reward one receives from the organisation and the experience one has to undergo in the process. If a person discovers that he cannot obtain the reward he originally had desired, he either leaves the organisation and joins another, or if this is not feasible, he accepts the reward which he can obtain and at the same time remains less committed to that organisation. On the other hand, obtaining the desired reward enhances his obligation to the organisation and thus, his commitment is further strengthened.

Organisational commitment is predicted by the leader's behaviour (Tao, Takagi, Ishida, & Masuda, 1998). A leader who is perceived to exhibit a high level of initiating structure by providing excessive directions to employees, may reduce their autonomy and responsibilities. This may cause employees to be less committed (Rosin & Korabik, 1991). Commitment increases only if the leader realises the values and goals of the organisation and behaves in a supportive/participative manner (Sharma, 1989; Singh, 1990), involve his subordinates in the decision-making process (Srivastava, 2003) and creates conducive and caring climate (Rhoades, Eisenberger & Armeli, 2001). Initiating structure is necessary during the crisis time while consideration is desirable during normal or routine time (Marries & Sherman, 1981).

The F leader neither gives autonomy nor provides responsibilities to subordinates. He does not give much importance to subordinates but attaches more importance to his position and power. He wants the job to be done in order to safeguard his position. The NT leader, on the other hand, is task-minded. He structures the role of his subordinates, and directs them towards the goal. He drives the subordinates to work hard and at the same time cares for their development. He not only cares for his subordinates but also equally looks after the interests of the organisation. The P leader also gives full freedom and responsibilities to his subordinates and invites them to come forward. He gives them full opportunity to grow, and allows them to show their efficiency to realise the norms and values of the organisation.

Hypothesis 1: Organisational commitment of subordinates would increase under NT and P leader and would decrease under F leader.

(ii) Job Satisfaction

Job satisfaction or dissatisfaction is the result of various attitudes a person holds towards job-related factors. The job-related factors are dealt within the two-factor theory. Motivators or intrinsic factors are those factors which an employee experiences while doing the job: recognition, interesting nature of work, work responsibilities and scope for career advancement. The presence of these factors satisfies the employees. The extrinsic factors, which do not relate to employees' motivation and satisfaction, are company policy, supervision, salary, working condition, and inter-personal relations. However, job satisfaction as well as dissatisfaction of some employees resides either in a few or all-extrinsic job factors of other employees, either in a few or all intrinsic job factors, and of still others in a combination of both the factors (Suar, 1993). Job satisfaction of employees are affected by leader's behaviour (Skaret & Bruning, 1986). A leader who possesses technical competence, establishes initiating structure, and shows consideration to the subordinates, tends to increase the expectations and job satisfaction of subordinates (Schrieshlim & Murphy, 1976). Also, a leader increases employees' job satisfaction if he allows participation (Singh & Pestonjee, 1990), creates a good organisational climate (Srivastava, 1987) and improves human relations (Sinha & Singh, 1995). Furthermore, employees are satisfied with the leader who supports, clarifies role expectations, creates group cohesiveness and gives value to rewards (Podsakoff, Mackenzie & Bommer, 1996).

Job satisfaction or dissatisfaction is the result of attitudes a person holds towards job-related factors.

Job satisfaction is reported to be high under P or the democratic or employee-centred leader or relationship-oriented behaviour (Bass, 1981; Sinha & Choud-

hary, 1981; Yukl, 2001). Employees' job satisfaction decreases when the leader provides low responsibility and autonomy to subordinates (Rosin & Korabik, 1991) and does not share their feelings (Mayfield, Mayfield, & Kopf, 1998). A participative leader like an employee-oriented leader is friendly by nature and allows free and frank discussion. He is fact-minded in administration of rewards. He seeks full participation of subordinates to decide the time, task and resources. The subordinates work without any anxiety and tension and feel happy and comfortable in the group. The NT leader gives importance to the task and also takes care of subordinates. His emphasis on task achievement may induce anxiety and may not increase subordinates' job satisfaction. The F leader decides the extrinsic and intrinsic factors in job and gives rewards to whoever he likes. He believes in power and position, and maintains a distance from subordinates. Subordinates feel frustrated working under him.

Hypothesis 2: Job satisfaction of subordinates would increase under P leader.

(iii) Challenging Task

Challenging task can be characterised by (a) lot of constraints, (b) risk, (c) difficulty and (d) performance under critical conditions. Challenging tasks are not only risky and difficult but also require extraordinary efforts on the part of employees to achieve the goals. Employees who want to soar in their careers accept challenging tasks. This means doing something very exceptional to fulfil self-actualisation need, or to be on the top of the ladder. If an employee is dedicated to his profession and gets encouragement, support, and suitable reward from his superior, he accepts and executes any challenging task, whatever the risk involved.

Challenging tasks are not only risky and difficult but also require extraordinary efforts on the part of employees to achieve the goals.

The NT leader, being task-minded and accomplishment-oriented, provides more enthusiasm and encouragement to his subordinates to take up challenging responsibilities. He derives the need of subordinates to its highest level. Therefore, subordinates under NT leader are likely to accept high challenging tasks rather than under the P leader. Subordinates are not likely to accept challenging tasks under the F leader because he provides neither encouragement nor rewards for task performance.

Hypothesis 3: Subordinates would accept challenging tasks under NT leader.

(iv) Work Centrality

Work centrality means how far work is important to an employee. Employees in India do not like to work unless they are asked or compelled to do so. They often come late to office and try to go back as early as possible. They take things very casually unless forced to be serious or punctual. During office hours too, they are not very serious about the work assigned to them. They do not consider work as important as family. For instance, if a family member is sick, family members bother a lot and take steps for his quick recovery but if a unit is sick, there is hardly any one who gives serious thought about overcoming that sickness. Altogether, employees hardly give any importance to work (Sinha, 1985). However, despite the dysfunctional work climate, subordinates under the P leader are likely to perform better because (a) they are assigned full autonomy and responsibility of work, (b) they are self-motivated to work and (c) the work accomplished by them is highly valued by their leader.

Hypothesis 4: Work centrality of subordinates would increase under the P leader.

(v) Intention to Quit

Intention to quit is the desire of the employees to leave the organisation or discontinue the service, or an unwillingness to extend the service. Intention to quit leads to voluntary turnover and absenteeism (Michaels & Spector, 1982). Stressful organisational climate directly contributes to one's intention to quit the organisation and caring organisational climate creates for favourable conditions for employees to remain in the organisation (Rhoades, Eisenberger & Armeli, 2001). However, a large part of intra-organisational variables affects job satisfaction, which in turn affects one's intent to quit. (Hendrix, Ovalle & Troxler, 1985). Employees, who describe their job as having low responsibility and autonomy, express a greater intention to quit the organisation (Rosin & Korabik, 1991).

Subordinates are likely to quit the organisation under F leader because the leader enjoys absolute power, and provides no autonomy to the subordinates. He wants subordinates to depend on him. He creates a stressful climate where subordinates do not like to perform their duties willingly. On the other hand, P leader maintains good interpersonal relationship with subordinates. He seldom criticises or demoralises his subordinates in any manner. He is polite and creates a friendly and stress-free climate,

where subordinates like to discharge their duties with alacrity wilfully. NT leader is tough but he too takes care of subordinates.

Hypothesis 5: Subordinates' intention to quit the organisation would increase under F but decrease under the P leader.

(vi) Target Realisation

Target realisation is the extent to which an employee perceives that he has achieved the target in time (Verma, 1995). It implies that an employee should understand the target set by the organisation, and perceive the direction to achieve the set target in time. Employees whose values match with the values of the organisation and who work in a favourable climate realise higher targets (Pandey, 1989; Varma, 1995). Subordinates' values are better understood by the NT leader, who not only honours their values, but also inspires them to achieve the set goals in time. A leader can achieve target if he is willing to patiently guide, supervise and instruct clearly the subordinates on all relevant tasks that have to be performed (Sinha & Kanungo 1997). Sinha (1985) emphasised that NT leader is task-minded and target-oriented. Hence, subordinates working under NT leaders are likely to achieve the set target on time. Even if the P leader works together with subordinates and enjoys their full co-operation and co-ordination, he himself does not put emphasis on target realisation; rather it is decided by the group members. Also, target realisation is likely to be low under the F leader, because the F leader is self-oriented and creates an unfavourable organisational climate. Instead of paying attention to the target, he pays attention to his own position in the group.

Hypothesis 6: Target realisation of subordinates would increase under NT leader.

(vii) Hard Work

Hard work means voluntarily putting in extra effort on the job. It is a habit of working hard (Landis, Triandis & Adampoutos, 1978) or behavioural intention to work hard in debilitating conditions. It is an automatic response to a situation and does not require any instructions (Triandis, 1984). Hard work is influenced by cultural values one imbibes through socialisation. It is determined by three sets of considerations – social, emotional and cognitive. Hard work cannot be visualised by putting pressure on employees. But it is an inner interest aroused by employees' self-motivation, group effectiveness or the situation in which employees' works.

The P leader seeks participation of subordinates in decision-making for task accomplishment. Subordinates manage the allocated responsibilities. This gives them a sense of ownership and generates the will to implement the decision and to do the task. Since the NT leader is task minded, he drives his subordinates to work hard (Sinha, 1980). On the contrary, the F leader decides the job by himself and expects the group members to execute it. He uses threat and punishment, and induces fear in the minds of subordinates for task completion.

Hypothesis 7: Subordinates would work harder under P and NT leaders than under the F leader.

Method

Sample

Permission to collect data was sought from the competent authorities of two identical units of the Indian Air Force (IAF). One was located in eastern and the other in the western region of India. Using random sampling procedure, 100 officers and 400 airmen were selected for response. They were approached individually and briefed about the purpose of study. Questionnaires were distributed among them. Respondents were assured time and again about the complete anonymity of their responses. They were requested to give their response freely to each item and return the filled in questionnaire within a fortnight. The questionnaires were collected personally. The total number of questionnaires returned was 75 from officers and 287 from airmen, representing a response rate of 72.4 per cent. There were a few female employees in the organisations (units). However, they were excluded from sampling for the sake of uniformity.

Table 1: Sample Characteristics of employees

Level	Mean & range	Age	Total service (in years)	Formal study (in years)	Basic salary	No. of promotions	Average family size
Airmen	Mean	32.48	13.33	13.27	1488.73	2.10	3.61
	Min	19.00	2.00	10.00	950.00	0.00	1.00
	Max	55.00	34.00	18.00	2300.00	4.00	8.00
Officers	Mean	33.97	14.18	16.16	3383.00	2.50	3.53
	Min	25.00	3.00	14.00	2400.00	1.00	1.00
	Max	35.00	25.00	20.00	4800.00	4.00	5.00

362 sample characteristics of employees (Table 1) reveal that most of the employees are married and are graduates. Officers are more educated, more ex-

Table 2: Number of items, mean of total items, content validity and reliability of different measures

Construct	Variable	No. of item(s)	Mean of total item(s)	Correlation of each item score with total item score		Cronbach's alpha
				Minimum	Maximum	
Leadership Style	Authoritarian	9	25.08	.37**	.68**	.73
	Nurturant-task	10	23.68	.54**	.75**	.87
	Participative	10	18.91	.58**	.79**	.88
Work Behaviour	Organisational Commitment	10	32.46	.45**	.73**	.78
	Job satisfaction	18	53.82	.36**	.71**	.87
	Challenging task	6	22.25	.53**	.69**	.65
	Work centrality	1		Semi-projective test		
	Intention to quit	4	10.25	.67**	.78**	.74
	Target realisation	2	7.68	.87**	.89**	.70
	Hard work	1	-	-	-	-

perienced and are getting more basic salary than airmen. Though the promotion avenues were open to both, officers were quicker at getting promotion than airmen. Barring a few, both the groups had small families.

Procedure

After taking permission from the competent authority of the organisation, the researcher visited all the departments. Appointment was fixed well in advance with each respondent separately. At the very outset, the respondents were briefed about the purpose of the study. They were assured that the present study was being carried out for academic purpose only. Information and opinions provided by them would be kept strictly confidential. Respondents were assured time and again about the confidentiality of the information furnished by them due to the sensitive nature of the organisation. They were requested to give their responses frankly to each item and fill-up the questionnaire in detail without mentioning their names. They were further assured that in the process of data analysis, information and opinions expressed would not be disclosed and the conclusion derived would be generalised.

The questionnaire prepared to collect data for the present study consisted of different variables of leadership and work behaviour. The questionnaire began with an introduction and brief objectives of the study. Three variables (F, NT & P) were taken to check leadership styles. Seven variables - organisational commitment, job satisfaction, challenging task, work centrality, intent to quit, target realisation and hard work were conceptualised to measure work behaviour of subordinates. The first five variables of work behaviour assessed the attitudes/feelings towards various aspects of work and the last two variables evaluated the performance related to work/job.

Measuring Leadership Style

F, NT and P styles were measured using 30 items. These items were drawn from a 50-items questionnaire developed by Sinha (1987) to measure five styles. Ten-items were used to measure each style. Sinha's scale measured the leadership style asking the leaders to respond to the leadership questionnaire. In this study, the subordinates were asked to evaluate their immediate superior on three styles. Sample items measuring F style include: "My superior keeps the important information to himself" and "My superior thinks that he is always right in making decisions." Sample items measuring NT style include: "My superior gladly guides and directs those subordinates who work hard" and "My superior feels good when he finds his subordinates eager to learn." Sample items measuring P style include: "My superior often consults his subordinates" and "My superior allows his subordinates to solve a problem jointly." All the items were positively keyed and a five-point Likert-type scale running from never (0) to always (4) was used. All items measuring NT and P style were retained. Each item score correlated significantly among themselves and with the total score of all items. The alpha reliabilities for NT and P scales were found to be .87 and .88 respectively. But, one item measuring F style was dropped in the final analysis. The item "My superior makes it clear to the subordinates that personal loyalty is an important virtue" correlated insignificantly with six items in F scale, even if the item had significant content validity ($r = 0.30$, P .01). Moreover, when the item was dropped from the scale, the alpha reliability of the scale increased from .71 to .73. Thus, the three styles were measured using 29 items - 9 for F style, 10 for NT style and 10 for P style (Table 2). Higher scores indicate greater exhibition of the style by the superior.

Work behaviour

(i) Organisational Commitment:

Ten items were used to measure organisational commitment. Nine items were drawn from the organisational commitment questionnaire (Mowday, Steers, & Porter, 1979) and one item "I support the extra curricular activities organised by this organisation" was added. Each item was scored on five-point Likert-type scale ranging from strongly disagree (1) to strongly agree (5). Seven items were positively scored and the remaining were negatively scored. Positively keyed sample items include: "I am willing to put in a great deal of effort beyond the call of my duty in order to help this organisation" and "I am proud to tell others that I am a part of this organisation." Negatively keyed sample items include: "Deciding to work for this organisation was a definite mistake on my part" and "Often, I find it difficult to agree with organisation's policies on important matters relating to its employees." The scores of the items correlated significantly among themselves. The score of each item also correlated significantly with the total score of item as a measure of content validity. The coefficient alpha of the scale was 78 (Table 2). Higher scores indicate greater organisational commitment.

(ii) Job Satisfaction

Job satisfaction was measured using a 8-item questionnaire. Fifteen items were taken from job satisfaction scale (Kanungo, Mishra, & Dayal, 1975) and three items were further added. There were ten organisationally controlled extrinsic job outcomes: working condition (illumination, ventilation, noise etc.), hours of work, basic salary, organisational policy, job security, fringe benefits, promotion opportunity, leave facility, accommodation and welfare facilities. The last three extrinsic job outcomes were added to the scale. There were four interpersonally mediated extrinsic job outcomes: general supervision, technical supervision, interpersonal relationship, respect and recognition from superiors, colleagues and subordinates. The remaining four job outcomes were intrinsic in nature: responsibility, achievement, advancement and interesting nature of work. On each of the job outcomes, employees indicated their level of satisfaction and dissatisfaction on a five-point Likert-type scale ranging from highly dissatisfied (1) to highly satisfied (5). The scores of the items related significantly among themselves. As a measurement of content validity, score on each item correlated significantly with the total score of the items. The coefficient alpha of the scale was 87 (Table 2). Higher scores indicate greater job satisfaction

(iii) Challenging Task

A six-item scale was developed to measure challenging task that assessed the attitude towards constrained, risky and difficult tasks. Sample items include: "I accept the task that is most difficult to perform" and "A distaste for challenging task reflects weakness of character". Each item was evaluated on a five point Likert-type scale running from completely disagree (1) to completely agree (5). The score of each item correlated significantly with the score of other items. Each item score correlated significantly with total items score. Thus content validity of the item was highly significant and coefficient alpha was.65 (Table 2). Higher scores indicate greater preference for challenging task.

(iv) Work Centrality

The item was semi-projective in nature and developed by Sinha (1990). Work centrality rating is jointly determined by job-specific affect, cognition, and activity ratings. Keeping in mind the global nature of the centrality judgement, the officers and airmen, instead of being asked to use a rating scale, were provided with a circle (47 mm radius) in which they were to locate their centrality work, assuming the circle to be their life space. Work centrality was derived by measuring the distance (in mm) of the point of location from the centre and then by subtracting the score from the maximum possible score of 47 mm. Thus, higher the score, the greater the centrality. The possible range of scores was from 0 to 47.

(vi) Intention to Quit

A four-item scale was developed to measure the intention to quit that evaluated the desire to leave the organisation. Sample items include: "How often do you think of quitting your present organisation?" and "How frequently are you applying for jobs in other organisations?" Each item was measured on a five-point scale. The response categories against each item were varied. For the first item in the scale, the response categories ranged from never (1) to always (5) and for the last sample item, from not at all (1) to four or more than four times in a year (5). Three items were positively keyed and one item was negatively keyed. The scores of items correlated significantly among themselves with other items and with the total score of the items. The coefficient alpha was .74 (Table 2). Higher scores indicate a greater intention to quit the organisation.

(vii) Target Realisation

Two items, developed by Pandey (1989) measured target realisation that evaluated the target realised by

Table 3: Relationship between Leadership Styles and Work Behaviour of Airmen and Officers

Leadership Styles	Employees	Work Behaviour						
		Organisational Commitment	Job satisfaction	Challenging task	Work centrality	Intention to quit	Target realisation	Hard work
F	Airmen	-.26**	-.25**	.00	-.10	.27**	-.03	-.03
	Officers	-.41**	-.55**	-.11	-.10	.54**	-.17	-.00
NT	Airmen	.31**	.41**	.25**	.17**	-.22**	.23**	.03
	Officers	.57**	.51**	.28**	.00	-.44**	.10	.15
P	Airmen	.39**	.50**	.22**	.24**	-.35**	.15**	.10
	Officers	.62**	.63**	.25**	-.10	-.59**	.08	.01

* p .05 (two-tailed) ** p .01 (two-tailed)

the employees and by the department. The two items include: "How often is your department able to achieve the target set for your department?" and "How often are you able to achieve the target set by you?" Each item was scored on a five point Likert-type scale ranging from not at all (1) to always (5). Both the items were positively scored. The score of the two items correlated significantly among themselves and with the total score of the items. The coefficient alpha of the scale was.70 (Table 2). Higher scores indicate greater effort expansion for target realisation.

(viii) Hard Work

Hard work was measured by an item developed by Sinha (1980) that assessed the willingness to work hard. The item was "How hard do you work?" The item was scored on a four-point scale ranging from work very leisurely (1) to work very hard (5).

Results

Leadership Styles and Work Behaviour of Airmen and Officers

While computing correlation between leadership styles and work behaviour of airmen and officers (Table 3), the results reveal that airmen become less committed, less satisfied and express unwillingness to remain in the organisation under F leader. Under NT and P leaders, airmen become highly committed, express willingness to accept challenging tasks, show more centrality towards work and experience increased job satisfaction. Also, airmen show higher target realisation and lower intention to quit the organisation under NT and P leaders. The correlations are similar in case of officers too. Officers become less committed, less satisfied and express more willingness to leave the organisation under F leader. But they become highly committed, satisfied with jobs, realise the higher target and accept challenging tasks under NT and P leaders. Officers do not express the desire to quit the organisation, when the leader is NT or P.

In conclusion both airmen and officers do not express willingness to remain in the organisation when they work under F leader. However, they remain happy and express the desire to continue their service effectively when they perceive their leaders to be NT or P type.

Work Behaviour Predicting Leadership Styles

Linear regression by backward elimination (Table 4) reveals that perceived F and P styles significantly explain 17% of the organisational commitment of airmen. Perceived NT and P styles of supervision explain 42% of the organisational commitment of officers. When airmen perceive their immediate superiors to be less authoritarian and much more participative, they feel committed to the organisation and to their jobs. F style of a leader diminishes the organisational commitment of airmen whereas the P leader enhances the same. The standardised beta coefficient indicates that P style of the leader is a major contributor that increases organisational commitment of airmen. But officers' perception of their immediate superior as NT or P predicts significantly their organisational commitment. These two styles that dominate at officers' level predict organisational commitment. The standard beta coefficient reveals that P style of superiors predicts the organisational commitment of employees prominently irrespective of levels. Thus, hypothesis H1 is confirmed.

P style of supervision explains 25% and 39% of the job satisfaction of airmen and officers respectively. When airmen and officers perceive that their immediate superior is participative, they feel more satisfied with their jobs. The earlier product movement correlations (Table 3) pointed out that job satisfaction decreases

Table 4: Summary of Regression Analysis for Work Behaviour Predicting Leadership Styles

Work Behaviour	Employees	Leadership style									R2	F
		F			NT			P				
		B	SEB	*Beta*	B	SEB	*Beta*	B	SEB	*Beta*		
Organisational commitment	Airmen	-.17	.07	-.13	-	-	-	.29	.05	.34**	,.17	28.67**
	Officers	-	-	-	.32	.15	.26*	.42	.12	.44**	.42	26.01**
Job Satisfaction	Airmen	-	-	-	-	-	-	.78	.08	.50**	.25	95.12**
	Officers	-	-	-	-	-	-	.96	.14	.62**	.39	47.00**
Challenging Task	Airmen	-	-	-	.11	.03	.25**	-	-	-	.06	18.55**
Work	Officers	-	-	-	.17	.07	.28**	-	-	-	.08	6.29**
Centrality	Airmen	-	-	-	-	-	-	.33	.08	.24**	.06	18.05
	Officers	-	-	-	-	-	-	-	-	-	-	-
Intention to Quit	Airmen	.10	.04	.17**	-	-	-	-.12	.03	-.29**	.14	24.00**
	Officers	-	-	-	-	-	-	-.15	.05	-.41**	.37	21.49**
Realisation	Airmen	-	-	-	.04	.01	.23**	-	-	-	.05	15.74**
	Officers	-	-	-	-	-	-	-	-	-	-	-
Hard work	Airmen	-	-	-	-	-	-	-	-	-	-	-
	Officers	-	-	-	-	-	-	-	-	-	-	-

* p .05 (Two-tailed) ** p .01 (Two-tailed)

under F leader and increases under both NT and P leaders, irrespective of level of employees. But the magnitude of correlation points out the importance of P compared to NT leader. The regression analysis adds further support and predicts that only the P leader brings more job satisfaction to the subordinates. Thus, hypothesis H2 is substantiated.

The relationship between leadership style and challenging task reveals that the acceptance of challenging tasks increases for airmen and officers when their superiors are NT and P types. But the magnitude of the correlations unfolds the fact that the preference for challenging tasks increases more under NT than under P leader (Table 3). The regression analysis brings the findings into sharp focus. Only NT leader significantly (R2 = .06, 08,; F = 18.55, 6.29, p.01) predicts the challenging task of subordinates (Table 4). That means acceptance and accomplishment of challenging tasks takes place only under a task-oriented leader. These results confirm hypothesis H3.

Work centrality of airmen increases when they find that the leader plays NT and P styles. Taking the magnitudes of correlations into account, the regression analysis confirms that only the P style of the leader predicts the work centrality of airmen (R2 = .06, F = 18.05, P.01). That means airmen consider the job central to their lives, when they perceive their leader is supportive, co-operative, close to them and understand their problems. In such cases, the airmen internalise the value of work, goal of organisation and consider the job pivotal to their lives. These findings do not hold good at the level of officers. Thus, the results support the hypothesis H4 at the level of airmen only.

The correlation between leadership style and intention to quit the organisation reveals that under the F leader, the desire to quit the organisation increases, whereas under NT and P such desire decreases. This is applicable to both airmen and officers. The desire to quit the organisation decreases more sharply under P than under NT leader (Table 3). This trend is prominently confirmed in step-wise regression analysis. The F style of the superior significantly increases intention of airmen to quit the IAF (B = .17, p.01, R2 = .14, F = 24.01, p.01) whereas the P style of the superior drastically reduces the intention of airmen to quit the same organisation (B = -.29, R2 = .14, F = 24.00, p.05). That means when airmen find that the leader is F, their willingness to remain in the organisation decreases. Just the opposite happens under the P leader. When officers find that the leader is P, their intention to remain in the organisation and continue the service increases. For both airmen and officers, P style emerges as a distinct cause to remain in the organisation, whereas F style influences the intention of airmen to quit the organisation. Thus, hypothesis H5 is confirmed.

The correlation between leadership style and target realisation reveals that target realisation of airmen increases sharply under NT than under P leader. NT or other styles do not influence the target realisation of officers (Table 3). Further, regression analysis confirms that under NT style, airmen realise the set target ($R2 = .05$, $F = 15.74$, p.01) (Table 4). These findings are similar to the finding of Sinha (1985). But none of the styles of senior officers influences the target realisation of officers, because officers are responsible and mature enough to understand the norms and values of the organisation. They are competent, energetic and self-motivated to achieve the set target timely. Therefore, none of the styles of senior officers either increases or decreases the target realisation of officers. Thus, hypothesis H6 is partially confirmed.

The correlations and regression analysis reveal that none of the leadership styles influences hard work of airmen and officers (Table 3 & 4). That means airmen and officers continue to put their extra efforts in the job irrespective of leadership styles. Thus, hypothesis H7 is refuted.

Discussion

Many factors affect leadership styles such as organisational set-up, situational requirements, nature of task, characteristics of subordinates and demands from the top. These factors compel the leader to behave in a particular manner, which he or his subordinates may not like. Results indicate that the F leader exhibits least concern for subordinates and uses his power to get the job done, he often interferes with the work of airmen and directs them to work accordingly. Thus, his supervisory style reduces the commitment of airmen working under him. This is supported by other findings (Cannon, 1998). On the other hand, NT leader supports, guides and encourages the employees to develop and participate in organisational activities. His supervisory style increases the commitment of officers. This is in line with the findings of Sinha (1981). P supervisor, who realises the values and goals of the organisation, gives full autonomy and responsibilities to his subordinates. He invites participation of subordinates and encourages airmen and officers to mingle with one other. He also shares the organisational vision and values associated with them. Therefore, organisational commitment increases under P leader. Other investigators (Rosin & Korabik, 1991; Sharma, 1989; Singh, 1990) support these findings.

When airmen and officers perceive their leader to be participative, their job satisfaction increases because the P leader is supportive in nature, allows full participation, creates a friendly and cohesive group climate, where subordinates like to work willingly. He understands the values of subordinates and rewards them suitably. He gives them full responsibility, job autonomy to come up and understand the purpose and goal of the organisation. He also shares the feelings of subordinates. Therefore, airmen and officers remain happy and feel satisfied with their job under the P leader. These findings are similar to the findings reported in other studies (Bass, 1981, Mayfield, Mayfield, & Kopf, 1998; Podsakoff, Mackenzie, & Bommer, 1996; Rosin, & Korabik, 1991; Singh, & Pestongjee; 1990; Sinha, & Choudhary, 1981; Srivastava, 1987). Moreover, as the job level increases, satisfaction increases too (Robie, Ryan, Schmieder, Parra & Smith, 1998). That is why officers report higher job satisfaction than airmen.

Airmen and officers are well prepared to accept challenging tasks under NT leader. The NT leader is basically a task-minded leader. He provides enough support, guidance and encouragement to his subordinates to lead and win the game. He creates a climate of purposiveness and goal-orientation in subordinates and prepares them to accept challenging tasks. The NT leader also gives high rewards for high performance. Thereby, acceptance and accomplishment of challenging tasks of airmen and officers increases under the NT leader.

Work centrality of airmen increases under P leader. P is a relationship-oriented leader. He believes in group harmony and freely mingles with his subordinates. His concern for and involvement with subordinates' affairs make them aware of their roles and responsibilities. Subordinates reciprocate with the leader's call to complete the job/task and accept the job as their own. Hence, work centrality of airmen increases under P leader.

Airmen express their willingness to leave the organisation under F leader, because he is power-minded and rigid. He extracts work through fear and punishment. He does not seek subordinates' participation. Airmen feel frustrated working under such a leader and express willingness to leave the organisation. On the contrary, they prefer to remain in an organisation under the P leader because of his soft, humane and democratic approach. He invites the subordinates' suggestions, ideas and knowledge for task achievement. Thus, he creates a stress-free environment. Airmen and officers feel satisfied to continue in the organisation under P leader. Similar findings are reported by other investigators (Bass, 1981; Sinha & Choudhary, 1981; Yukl 2001).

NT leader predicts the target realisation of airmen significantly. NT leader mobilises his group members to

make serious efforts to realise the group goal(s). He defines the goal(s) and leads the group for goal-realisation. He openly praises and encourages those subordinates who realise the targets in time. NT leader, therefore, fosters a culture for goal-attainment and target-realisation.

Leadership styles do not influence and predict the amount of extra effort (hard work) put in by airmen and officers. Every employee in the organisation, irrespective of levels, is always putting in their best possible effort to do their jobs and keep the IAF shining, in order to "touch the sky with glory". It has been discussed earlier that the airmen and officers do not differ in the extent of hard work put in on their jobs. That is why, the leadership styles could not predict hard work of airmen and officers.

On the whole, under F leader, intention to quit the organisation increases, whereas under NT leader, target realisation of airmen, and preference for challenging tasks of both airmen and officers increases. Under the P leader, work centrality of airmen, organisational commitment of both airmen and officers' increase, and intention to quit decreases. Thus, the negative dimensions of work behaviour of subordinates increase under F leader and positive dimensions of work behaviour of subordinates' increase under NT or P leaders. It is found that the NT style overlaps with P style, whereas both NT and P styles have negative relationships with F style. That means, a leader can shift his style from NT to P or vice-versa depending on the work behaviour required from the subordinates. For instance, the leader can be NT if he wants a challenging task to be completed by subordinates, whereas he has to be P if he wants to increase the organisational commitment and job satisfaction of subordinates. However, a leader cannot shift his style from F to either NT or P, or the other way round.

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Whether you're rich or whether you're poor, everybody wants a bargain.

– John R. McMillin

Feature

Inter-State Variations in Factor Productivity in the Indian Manufacturing Sector during the Post-Reforms Period

Hina Sidhu

This study examines the factor productivity in the post-reforms period across the states keeping in view the concentration of industrial activities in the respective states. Total Factor Productivity (TFP) is obtained through the Direct Method, which is the geometric mean of the partial factor productivities of capital and labour. The TFP index recorded a steady growth in some states, while in certain states it recorded a steep decline. The study concludes that the overall TFP in the manufacturing sector in the post-reform period recorded a declining trend at the national level.

Hina Sidhu is Reader at the Department of Economics, Gujarat University, Ahmedabad.

The process of liberalisation in the manufacturing sector in India was initiated in the mid-1980s when the government of India delicensed certain industries, relaxed the rules for import of technology, increased the ceiling of capital investment and announced the need for reforms in the public sector undertakings. After the announcement of the liberalization policy in 1991, the government took all possible measures to bring rapid and sustained growth of output leading to employment generation so as to reduce poverty in the country.

In the public sector units, the implementation of reforms started with the disinvestments of some of the government equity in selected public sector enterprises. Some amendments were made in the labour laws to facilitate the industrial units to restructure themselves by laying off workers if necessary. The growth of information technology not only brought down the cost of office automation, but also proved cost effective as it increased the worker's efficiency and reduced duplication of work. It also contributed to the displacement of workers. With a view to creating job opportunities for the unemployed and displaced workers, the Government of India set up the National Renewal Fund.

The impact of the reforms on the industrial sector is apparent from table 1. The average size of the factory sector units in terms of employment declined steeply from 75 in 1995-96 to 60 persons by the year 2001-02. Fixed capital per unit (at 1993-94 prices) increased from Rs. 2.29 crore in 1995-96 to Rs. 2.59 crore in 2001-02. Similarly productive capital per unit increased from Rs. 2.99 crore in 1995-96 to Rs. 3.19 crore in 2001-02. This indicates the installation of improved technology in the new units and upgradation of the production process in some existing units. The value of output per rupee of investment in fixed capital increased from Rs. 1.79 in 1995-96 to Rs. 2.00 in 2001-02 and the value of output

Table 1: Size of ASI Factory Sector Units

Year	No. of factory Units	Employees per Unit (Nos)	Fixed Capital per Unit	Productive Capital per Unit	Fixed Capital per Employee (Rs. Lakh)	Productive Capital per Employee (Lakh Rs.)	Output per Unit (Lakh Rs.)	Output per unit of Fixed Capital (Rs.)	Output per unit of Productive Capital (Rs.)	Output per Employee (Lakh Rs.)	NVA per Employee (Lakh Rs.)	NVA/ Productive Capital (Rs.)
1981-82	105037	74	78.60	112.70	3.31	1.52	170.48	2.17	1.51	2.30	0.45	0.30
1991-92	112286	73	154.51	199.74	4.42	2.74	318.60	2.06	1.60	4.37	0.80	0.29
1995-96	134571	75	228.55	299.16	4.24	4.01	408.75	1.79	1.37	5.48	1.14	0.28
1996-97	132814	71	245.20	355.95	3.21	5.00	448.98	1.83	1.26	6.31	1.34	0.27
1997-98	136012	74	270.72	369.66	3.74	5.03	480.39	1.77	1.30	6.54	1.30	0.26
1998-99	131706	65	255.58	322.72	4.81	4.95	445.43	1.74	1.38	6.83	1.27	0.26
1999-2K	131558	63	264.24	332.49	4.87	5.30	497.48	1.88	1.50	7.93	1.37	0.26
2000-01	131268	60	239.32	302.33	4.80	5.01	498.32	2.08	1.65	8.26	1.28	0.26
2001-02	128549	60	259.08	319.30	5.30	5.34	518.86	2.00	1.62	8.68	1.30	0.24

per unit of productive capital increased from Rs. 1.37 in 1995-96 to Rs. 1.62 in 2001-02. Output per employee increased from Rs. 5.48 lakh in 1995-96 to Rs. 8.68 lakh 2001-02. All these indicate the impact of technological improvement on the industrial sector. However, the average size of ASI units in terms of fixed capital declined after 1997-98 which indicates that most of the new units commissioned during the 1998-02 period were of smaller size.

Another observation from Table 1 is that the ASI coverage of factory sector units has steadily declined since 1997-98 and the decline was significant in the year 1998-99. The steep decline in the ASI coverage and average factory size in terms of employment in 1998-99 could be due to two major reasons (a) closure of unviable units and (b) exclusion of industrial units related to power generation, transmission and distribution from the ASI two digit industry code 40 of the National Industrial Classification (NIC) 1987. The ASI factory sector data for the new classification of industry groups is available from 1998-99. Also most of the reforms in the industry sector were implemented by the year 1997-98. Therefore, for this study the post-1998-99 years are referred to as the post-reforms period.

Concentration of Manufacturing Activities in India

Considering the number of establishments and employment in the ASI factory sector units, the manufacturing sector in India has been dominated by eight groups of industries viz. food products, textiles, chemicals, rubber and plastics, non-metallic mineral products, basic metals, fabricated metal products and machine manufacturing. If we consider the contribution of each industry to the capital investment, the value of output and the value-added, then the manufacturing of coke and petroleum products is another industry of importance. This highly capital intensive industry has influenced the industrial growth in certain regions especially in Gujarat and Maharashtra.

Contribution of the aforesaid nine industry groups to the industrial sector in India is evident from Table 2. These nine groups of industries account for about 70% of the ASI factory sector units, 68 per cent of employment, 80 per cent of investment of productive capital, 77 per cent of value of output and 71 per cent of value-added by the industrial sector in the country. Andhra Pradesh, Gujarat, Maharashtra, Tamil nadu and Uttar Pradesh are the five highly industrialized states where most of the industrial activities are concentrated (Table 3).

Table 3 also reveals that the food products and beverages is an important industry in the country as 18.3% of the industrial units covered by the ASI factory sector are engaged in the activities related to food products and beverages manufacturing. Of the total food products and beverages units in India, nearly 25% are concentrated only in Andhra Pradesh. Tamil Nadu (13.7%) and Maharashtra (9.3%) are the other two states having relatively higher concentration of food products and beverages manufacturing activities.

Textile industry has nearly 10% share in the ASI units. This industry has a high concentration in Tamil Nadu (34.1%), followed by Gujarat (13.8%) and Maharashtra (10%).

Table 2: Industry-wise Indicators of Importance in the Year 2001-02

NIC Code	Industry	No. of ASI Units	% of Units	% of Emplo-yees	Productive Capital (%)	Value of Output (%)	Value of Added (%)	PFP_K Ratio	PFP_L Ratio	TFP Ratio
01	Agriculture, hunting and related service activities	3155	2.45	1.34	0.20	0.48	0.22	0.29	0.21	0.25
14	Other mining and quarrying,	88	0.07	0.08	0.01	0.01	0.02	0.54	0.37	0.45
15	Manufacture of food products and beverages	23485	18.27	16.86	8.83	15.61	11.30	0.35	0.87	0.55
16	Manufacture of tobacco products & tobacco related products	2477	1.93	6.36	0.42	0.73	1.92	1.24	0.39	0.69
17	Manufacture of textiles	12557	9.77	15.25	10.09	10.63	9.16	0.25	0.78	0.44
18	Manufacture of wearing apparel; dressing and dyeing of fur	3283	2.55	4.09	1.25	1.69	2.24	0.48	0.71	0.58
19	Tanning and dressing of leather; manufacture of products	2348	1.83	1.89	0.71	1.19	1.01	0.38	0.69	0.51
20	Manufacture of wood and wood products except furniture	3162	2.46	0.68	0.19	0.29	0.20	0.28	0.37	0.32
21	Manufacture of paper and paper product	3379	2.63	2.17	2.08	1.48	1.59	0.21	0.94	0.44
22	Publishing, printing and reproduction of recorded media	2886	2.25	1.45	0.58	0.61	0.91	0.43	0.81	0.59
23	Manufacture of coke, refined petroleum products and nuclear fuel	885	0.69	0.89	12.23	13.44	6.48	0.14	9.45	1.16
24	Manufacture of chemicals and chemical products	10577	8.23	9.82	16.94	13.42	17.03	0.27	2.24	0.78
25	Manufacture of rubber and plastic products	7094	5.52	3.47	4.21	3.89	4.33	0.28	1.61	0.67
26	Manufacture of other non-metallic mineral products	11758	9.15	6.02	7.57	3.60	5.57	0.20	1.19	0.49
27	Manufacture of basic metals	6746	5.25	7.00	14.59	10.20	8.59	0.16	1.58	0.50
28	Mfg. of fabricated metal products, except machinery & equipments	7999	6.22	3.45	1.70	2.18	2.67	0.43	1.00	0.65
29	Manufacture of machinery and equipment n.e.c.	8832	6.87	5.28	3.74	4.36	6.23	0.45	1.52	0.83
30	Manufacture of office, accounting and computing machinery	185	0.14	0.25	0.47	0.69	0.82	0.47	4.15	1.40
31	Manufacture of electrical machinery and apparatus n.e.c.	4076	3.17	2.89	3.50	3.97	5.14	0.40	2.29	0.96
32	Mfg. of radio, television & communication equipment and apparatus	1114	0.87	1.31	2.91	3.21	3.83	0.36	3.79	1.16
33	Mfg. of medical, precision & optical instruments, watches & clocks	911	0.71	0.76	0.37	0.43	0.70	0.51	1.20	0.78
34	Manufacture of motor vehicles, trailers and semi-trailers	2736	2.13	3.24	4.67	4.21	3.92	0.23	1.56	0.60
35	Manufacture of other transport equipment	2093	1.63	2.16	1.75	3.16	3.85	0.59	2.30	1.17
36	Manufacture of furniture; manufacturing n.e.c.	2207	1.72	1.63	2.02	2.53	2.18	0.29	1.73	0.71
37	Recycling	65	0.05	0.02	0.01	0.02	0.00	0.21	0.33	0.27
40 & above others		4450	3.46	1.65	2.15	2.42	1.91	0.24	1.49	0.60
All industries		128549	100.00	100.00	100.00	100.00	100.00	0.24	1.35	0.57
Major industries (NIC 15+17+23+24+25 +26+27+28+29)		89933	69.96	68.04	79.90	77.33	71.36	0.27	1.29	0.59

Table 3: State-wise Concentration of ASI Factory Sector Units (Fig. In %)

Industry Code	01	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	OT	ALL
A. and N. Island								0.5																		0.1	0.02
Andhra Pradesh	27.6		24.7	14.7	2.8	0.9	3.9	4.9	10.8	7.5	4.0	7.3	8.4	19.5	5.8	6.7	5.5	3.2	6.2	5.7	2.0	4.1	1.6	2.9	26.9	8.4	11.1
Assam			3.3	0.4	0.2			1.4	0.3	0.7	1.7	0.4	0.3	2.2	0.7	0.4	0.4		0.5			0.1		0.4		1.0	1.1
Bihar			0.9	4.5	0.2		0.4	4.9	0.7	1.5	3.2	0.5	0.2	4.2	0.8	0.6	0.6		0.2				0.3	0.3		3.2	1.1
Chandigarh			0.1					0.1	0.3	0.3		0.1		0.1	0.5	0.8	0.5		0.3	0.3	0.4		0.4	0.3		0.5	0.2
Chattisgarh			2.3	1.4	0.1		0.4	1.9	0.8	0.3	1.7	0.5	0.4	0.6	3.3	0.9	0.4		0.5				0.7	0.6		0.7	1.0
Dadra & N Haveli					1.7			0.3	3.3	0.3	0.6	1.7	2.1	0.3	0.9	0.4	0.7	2.9	1.5	0.5	0.6			0.9		0.1	0.8
Daman & Diu			0.1		0.8	2.0	0.2	0.1	3.7	0.2		1.2	8.5	0.1	0.8	0.2	0.8	5.5	2.5	0.6	3.2	0.6		2.8			1.1
Delhi			0.5	0.8	0.8	16.9	7.1	0.2	1.8	7.7	0.3	1.2	3.1	0.3	2.1	3.5	4.3	3.3	5.3	13.0	5.4	7.1	3.9	4.8		4.0	2.7
Goa			0.3		0.2				0.9	0.5	0.4	0.8	0.7	0.2	0.7	0.3	0.3	2.6	0.5	1.8	2.2	0.4	0.3	0.7		0.2	0.4
Gujarat	15.2	10.6	5.4	8.8	13.8	2.8	0.4	8.3	11.3	5.4	7.4	19.7	12.4	11.9	14.1	11.6	18.8		11.1	8.3	12.0	4.0	7.6	10.2	66.8	5.9	10.9
Haryana	3.0		2.3	0.6	4.0	5.1	2.9	6.3	2.0	0.7	1.4	2.8	2.5	3.3	4.2	5.6	5.2	5.0	2.3	2.8	5.2	9.7	6.9	2.2		1.7	3.5
Himachal Pradesh			0.3	0.4	0.3	0.1	0.3	0.2	0.5	0.3		0.6	0.7	0.3	0.5	0.3	0.5	4.5	0.6	1.3	1.3	0.4		0.2		0.2	0.4
Kashmir			0.3	0.1	0.2			0.5	0.2	0.2	0.6	0.2	0.3	0.2	0.5	0.3	0.3		0.5	0.4				0.8		0.4	0.3
Jharkhand			0.3	1.4	0.1			1.5	0.2	0.5	26.2	0.6	0.7	3.3	2.7	0.8	0.5		0.2			3.8	0.2	0.2		1.8	1.1
Karnataka	6.2		5.7	2.6	2.5	18.6	2.0	5.8	5.3	5.0	2.2	3.8	5.1	3.9	4.1	6.4	6.2	10.1	9.8	17.1	13.4	7.7	3.7	4.7		5.4	5.4
Kerala			4.3	2.5	3.3	1.1	3.7	22.1	2.1	4.4	2.0	2.2	6.0	8.1	1.2	2.0	1.0	2.9	2.6	4.2	2.0	0.2	0.7	3.6		2.9	3.7
Madhya Pradesh	10.5		2.2	10.7	1.5	0.4	2.5	1.1	2.8	1.6	3.4	2.7	1.8	2.1	2.4	1.8	1.4		3.7	1.0	1.3	2.8	0.8	0.9		2.6	2.3
Maharashtra	23.1	16.2	9.3	4.5	10.0	17.6	4.7	7.0	18.3	23.2	15.9	18.0	16.3	6.3	14.5	20.2	17.9	30.9	20.2	16.5	22.9	24.0	14.8	29.8		9.1	13.9
Manipur								0.7						0.2												0.1	0.05
Meghalaya										0.1					0.1											0.2	0.03
Nagaland								1.3		0.4				0.3												0.2	0.1
Orissa	0.1		2.0	2.7	0.4			4.0	0.8	0.4	2.9	1.0	0.7	2.8	2.5	1.3	0.4		1.2			0.2	0.0	1.5		1.6	1.3
Pondicherry			0.2		0.2	0.1	0.9	0.1	0.9	0.4		1.1	1.4	0.1	0.5	0.4	0.1	9.0	0.7	0.7	1.2	0.1	0.6	0.9	6.3	0.2	0.4
Punjab		21.0	6.2		7.8	0.2	9.0	4.0	5.2	1.8	1.3	1.7	2.8	2.1	8.9	9.6	9.4		2.6	2.0	2.8	8.1	33.0	4.3		4.4	5.6
Rajasthan		52.2	2.1	1.2	8.7	3.0	1.6	1.6	2.6	1.2	2.2	3.0	2.9	12.7	5.1	1.9	1.9		3.7	1.7	2.9	1.5	1.5	8.3		2.0	4.1
Tamil Nadu	14.2		13.7	8.1	34.1	24.2	37.3	8.8	10.7	21.9	3.8	17.7	10.2	6.9	7.2	10.2	10.3	5.9	6.5	7.6	9.5	19.4	8.0	8.2		16.7	14.7
Tripura			0.2	0.5						0.3		0.1	0.1	1.0	0.1	0.1			0.1					0.2		0.4	0.2
Uttar Pradesh			7.1	15.6	4.1	6.1	14.3	4.7	9.3	6.7	10.0	7.2	7.2	5.0	7.1	8.1	6.6	10.2	8.8	10.0	5.2	4.1	7.8	6.7		16.7	7.1
Uttaranchal			1.2		0.1	0.1	0.1	0.9	1.0	0.2		0.5	0.4	0.5	0.5	0.3	0.2		1.0	1.0	1.4			0.6		0.9	0.5
West Bengal			4.9	18.5	2.5	1.0	8.4	6.7	4.1	6.2	8.6	3.5	4.8	1.6	8.4	5.2	5.8	4.0	6.8	3.5	4.8	1.7	6.8	3.3		8.5	4.8
All India	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
All India	2.5	0.1	18.3	1.9	9.8	2.6	1.8	2.5	2.6	2.2	0.7	8.2	5.5	9.1	5.2	6.2	6.9	0.1	3.2	0.9	0.7	2.1	1.6	1.7	0.1	3.5	100

Although the manufacturing of coke and refined petroleum products units represents only 0.7 per cent of the ASI units in the country, this industry has over 12% share in capital investment, 13 per cent share in output and 6% share in value-added in the industrial sector in the country. Over 26 per cent of the units in this industry group are located in Jharkhand and they are mainly coke producing units, while refined petroleum products manufacturing activities are concentrated in Maharashtra (16%), Uttar Pradesh (10%), West Bengal (8.6%) and Gujarat (7.4%).

Manufacturing of other non-metallic manufacturing industry has around 9% share in the total ASI factory sector units in India. Nearly 20 per cent of units in this industry are located in Andhra Pradesh followed by Gujarat (11.9%), Kerala (8.1%), Tamil Nadu (6.9%) and Maharashtra (6.3%).

Chemicals and chemical products manufacturing industry covers 8.2 per cent of the ASI units in the country. Nearly 20 per cent of the chemicals units in the country are located in Gujarat, followed by Maharashtra (18%), Tamil Nadu (18%) Andhra Pradesh (7%) and Uttar Padesh (7%).

Fabricated metal products, except the machine and equipment industry, has 6.2 per cent presence in the ASI factory sector units in India. Nearly 19 per cent of the units in this industry are concentrated in Gujarat followed by Maharashtra (18%), Tamil Nadu (10%) and Punjab (9%).

Rubber and plastics manufacturing industry has 5.5% share in the ASI units in the country. Of the total units in this industry, over 16 per cent are located in Maharashtra followed by Gujarat (12.4%), Tamil Nadu (10.2%), Andhra Pradesh (8.4%) and Uttar Pradesh (7.2%).

Manufacturing of basic metals industry represents 5.2% of the ASI units in the country. Nearly 15% of the units in this industry are located in Maharashtra followed by Gujarat (14.1%), Punjab (8.9%), West Bengal (8.4%), Tamil Nadu (7.2%) and Uttar Pradesh (7.1%).

It is apparent from the aforesaid that the concentration of different industries varies from one state to another. As such the structure of industrial units in terms of employment and capital intensity and their performance in terms of value added in the respective states will have a varying impact on the factor productivities in the respective industries in each state.

Concept of Productivity

The study of factor productivity plays a crucial role in the formulations of policies at the state as well as national levels since it quantifies the contribution of respective factors of production ie. capital and labour. Depending upon the nature of product and the process of production, different industries employ different combination of factor inputs. Due to stringent labour laws, competitive market environment and office automation at low costs, the employers prefer to install labour saving technology. This not only puts pressure on the limited capital resources, but also restricts the generation of employment opportunities.

In the capital intensive industries which use complex technology and employ specialised labour, the wage levels are high. In such industries the prime concern is the enhancement of labour productivity. On the other hand, in the labour intensive industries employing unskilled or semi-skilled workers with relatively low wage rate, the emphasis is always on the improvement of capital productivity. Since there are considerable variations in the factor intensities across different industries located in different states, the concept of Total Factor Productivity rather than Partial Factor Productivity becomes more relevant to examine the trends of industrial performance over the period of time.

Measurement of Productivity

Variations in factor productivities and major industries influencing the factor productivities in respective states have been discussed in this study. Total Factor Productivity (TFP) in this study has been measured by use of Direct method. Direct method of TFP is the geometric average of the partial factor productivities. Partial factor productivity is obtained by dividing value-added by the respective factors of production. If we define partial factor productivity of capital by PFP_K, partial factor productivity of labour by PFP_L, and total factor productivity by TFP, then

$$PFP_{Kt} = V_t/K_t$$

and $$PFP_{Lt} = V_t/L_t$$

where V_t = value added for the year t,

K_t = capital employed for the year t, and

L_t = labour employment for the year t.

Thus the TFP for the year t through the Direct Method will be calculated as

$$TFP_t = \sqrt{(PFP_{Kt})\,(PFP_{Lt})}$$

State-level data for the new series of the manufacturing sector (at two digit NIC) for the 1998-02 period were obtained from the Annual Survey of Industries (ASI) statistics for the factory sector units. This study has considered the investment of Productive Capital as the factor of production. Productive capital includes both fixed as well working capital. The reason for considering working capital is due to the fact that it plays an equally important role in the process of production.

For making the analysis comparable, the ASI factory sector statistics, which are available at current prices, were converted at constant prices by using the wholesale price index with 1993-94 base. The wholesale price index of machinery and machine tools was used to deflate the value of capital while the wholesale price index of manufactured products was used to deflate other financial data.

Analysis of Productivity Indices

Since the analysis is done for the period 1998-99 to 2001-02, the year 1998-99 is taken as the base for computation of productivity indices. Productivity indices clearly state the movements in factor productivities which have taken place over the study period. Because total factor productivity (TFP) takes into account the productive efficiencies of both capital as well as labour, it is a more comprehensive measure to understand the overall trends in productive efficiencies of the factors of production. Trends of partial factor productivity indices, however, provide an inference about the movements in TFPI because it is a composite index of capital productivity and labour productivity indices. The analysis of variation in partial as well as total factor productivities in the manufacturing sector across the states in India have been presented in the following sections.

Capital Productivity Index

Partial factor productivity indices of capital ($PFPI_K$) in the manufacturing sector in India has recorded considerable variations across different states in the post reforms period (Table 4a). $PFPI_K$ recorded an increasing trend in the states of Andhra Pradesh, Karnataka and Uttar Pradesh. The $PFPI_K$ declined steeply in Gujarat, Maharashtra, West Bengal, Jharkand, Chandigarh and Assam. In other states and Union Territories the $PFPI_K$ recorded major oscillations. In 1999-00 the $PFPI_K$ was higher than the base year (1998-99) in Andhra Pradesh, Himachal Pradesh Karnataka, Daman and Diu, Haryana, Madhya Pradesh, Pondicherry, Rajasthan, Tamil Nadu, Uttar Pradesh and Uttranchal. On the other hand the index of PFP_K was lower than the base year in Assam, Bihar, Chandigarh, Chhatishgarh, Dadra and Nagar Haveli, Delhi, Gujarat, Jharkhand, Kerala, Maharashtra, Orissa, Punjab and West Bengal. The national level decline in $PFPI_K$ capital was mainly caused by the fall in $PFPI_K$ in the major industrialized states especially Gujarat, Maharashtra and Punjab due to their larger share in industrial concentration. Similarly the variations in the $PFPI_K$ for the years 2000-01 and 2001-02 can be observed for each state from Table-4a.

Table 4a: Partial Factor Productivity Index of Capital

Sl. No.	States	Partial Factor Productivity Index of Capital			
		1998-99	1999-2000	2000-01	2001-02
1	Andhra Pradesh	100.0	103.2	107.0	109.5
2	Assam	100.0	88.5	39.9	47.8
3	Bihar	100.0	121.1	82.0	58.7
4	Chandigarh	100.0	85.7	73.9	59.0
5	Chattisgarh	100.0	59.5	90.4	46.9
6	Dadra & N Haveli	100.0	102.8	69.6	88.9
7	Daman & Diu	100.0	151.5	123.7	133.7
8	Delhi	100.0	97.6	82.3	85.9
9	Goa	100.0	84.4	83.6	94.9
10	Gujarat	100.0	103.2	89.6	75.9
11	Haryana	100.0	103.4	88.7	108.1
12	Himachal Pradesh	100.0	99.7	132.9	104.5
13	Jharkhand	100.0	102.9	52.9	47.0
14	Karnataka	100.0	109.2	119.0	128.4
15	Kerala	100.0	84.3	84.4	75.1
16	Madhya Pradesh	100.0	112.9	170.6	168.8
17	Maharashtra	100.0	92.7	93.9	89.6
18	Orissa	100.0	148.9	116.7	90.5
19	Pondicherry	100.0	68.4	92.1	112.3
20	Punjab	100.0	80.5	73.5	91.6
21	Rajasthan	100.0	109.1	129.9	118.4
22	Tamil Nadu	100.0	100.1	119.8	108.7
23	Uttar Pradesh	100.0	120.7	132.5	152.9
24	Uttaranchal	100.0	138.3	140.5	128.5
25	West Bengal	100.0	57.3	54.4	46.8
Total of Major States		100.0	100.8	99.6	95.1
Total Industrialised States *		100.0	99.5	99.7	90.2
All India		100.0	100.8	99.7	95.1

* Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu

The industry-wise examination of capital productivity at the national level for the year 2001-02 states that

the PFP_K was higher in the food products, chemicals, rubber products, fabricated products and machinery and equipment manufacturing industries (Table 2). On the other hand, the PFP_K was lower than the national average in the textiles, coke and petroleum products, non-metallic mineral products and basic-metals manufacturing industries. Their concentration in each states has influenced the overall state level $PFPI_K$ for the year 2001-02.

It is apparent from Table 4a that during the post reforms period the capital productivity in the manufacturing sector has registered a negative growth in many states and Union Territories. The analysis also states that the decline in the PFP_K at the national level is mainly caused by the fall in the PFP_K in Gujarat, Maharashtra and Punjab.

Labour Productivity Index

The index of the partial factor productivity of labour ($PFPI_L$) shows fluctuating trend in most of the states (Table 4b). At the national level the $PFPI_L$ recorded appreciable growth in the year 1999-00 but in the subsequent year (2000-01) the $PFPI_L$ dipped to almost 1998-99 level while in 2001-02 the $PFPI_L$ recorded a marginal increase. State-level analysis of the $PFPI_L$ shows considerable variations. The $PFPI_L$ has increased steadily in Himachal Pradesh and Madhya Pradesh. On the other hand the $PFPI_L$ recorded a steep decline in Dadra and Nagar Haveli, Jharkhand and Kerala. In the remaining states and Union Territories the $PFPI_L$ recorded considerable oscillations during the 1998-2002 post-reforms period. An inference from Table 2 is that in the year 2001-02 the industries which influenced the increase in labour productivity were mining and quarrying; food products; leather; coke and petroleum products; chemicals; rubber and plastics; basic metals; machinery and equipment; office accounting and computing machinery; electrical, radio, television and communication; motor vehicle and transport equipment and furniture manufacturing industries. On the other hand the industries which adversely affected the labour productivity were tobacco; textiles; wearing apparel; wood products; paper and paper products; publishing and printing; fabricated metal; medical precision and recycling industries. It is apparent from Table 2 that the PFP_L is considerably low in the industries related to agriculture and related services; other mining and quarrying; food products and beverages; tobacco and tobacco products; textiles; wearing apparel, dressing and dying of fur; leather and leather products; wood and wood products; paper and paper products; printing, publishing and reproduction of recorded media; other non-metallic mineral products; fabricated metal products except machinery and equipment and recycling activities. The impact of good or poor performance of the PFP_L in the respective industries have influenced the overall PFP_L at the State as well as at the National levels.

Table 4b: Partial Factor Productivity Index of Labour

Sl. No.	States	Partial Factor Productivity Index of Capital			
		1998-99	1999-2000	2000-01	2001-02
1	Andhra Pradesh	100.0	105.5	100.0	115.4
2	Assam	100.0	107.2	79.4	59.9
3	Bihar	100.0	140.4	98.2	83.7
4	Chandigarh	100.0	107.1	100.5	83.5
5	Chattisgarh	100.0	69.6	75.0	72.0
6	Dadra & N Haveli	100.0	91.5	68.6	59.1
7	Daman & Diu	100.0	134.1	108.5	115.3
8	Delhi	100.0	115.5	84.5	89.6
9	Goa	100.0	93.6	97.4	112.7
10	Gujarat	100.0	98.5	91.3	94.7
11	Haryana	100.0	146.0	120.2	144.5
12	Himachal Pradesh	100.0	104.7	120.7	126.4
13	Jharkhand	100.0	92.1	56.5	49.7
14	Karnataka	100.0	99.3	99.2	111.4
15	Kerala	100.0	80.6	74.0	71.3
16	Madhya Pradesh	100.0	139.2	156.8	179.1
17	Maharashtra	100.0	123.2	111.9	104.2
18	Orissa	100.0	135.0	117.9	106.6
19	Pondicherry	100.0	79.7	107.8	134.9
20	Punjab	100.0	103.9	73.1	93.1
21	Rajasthan	100.0	146.7	142.0	128.1
22	Tamil Nadu	100.0	107.6	113.1	101.8
23	Uttar Pradesh	100.0	103.4	99.3	107.1
24	Uttaranchal	100.0	131.4	188.1	167.2
25	West Bengal	100.0	95.9	95.4	107.5
Total of Major States		100.0	108.8	99.9	101.6
Total Industrialised States *		100.0	109.2	102.2	99.7
All India		100.0	109.0	100.1	101.8

* Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu

Total Factor Productivity Index

As stated earlier the Total Factor Productivity (TFP) in this paper is obtained through the direct method which is the geometric mean of the partial factor productivity indices of capital and labour. In the year 1999-00 the

$PFPI_K$ and the $PFPI_L$ were higher than the base year (1998-99). As a result the TFPI recorded increase over the base year. In the subsequent years the $PFPI_K$ recorded a declining trend while the $PFPI_L$ recorded marginal increase over the base year. Since the decline in the $PFPI_K$ was higher than the increase in the $PFPI_L$, the net effect was the decline in the TFPI during the years 2000-01 and 2001-02. This is apparent from the TFPI presented in Table 3c. Table 3c shows that in 1999-00 the TFPI was higher than the 1998-99 while TFPI was lower than the base year (1998-99) in the years 2000-01 and 2001-02.

Table 4c: Total Factor Productivity Index

Sl. No.	States	Partial Factor Productivity Index of Capital			
		1998-99	1999-2000	2000-01	2001-02
1	Andhra Pradesh	100.0	104.4	103.4	112.5
2	Assam	100.0	97.4	56.3	53.5
3	Bihar	100.0	130.4	89.7	70.1
4	Chandigarh	100.0	95.8	86.2	70.2
5	Chattisgarh	100.0	64.3	82.4	58.1
6	Dadra & N Haveli	100.0	97.0	69.1	72.5
7	Daman & Diu	100.0	142.5	115.8	124.2
8	Delhi	100.0	106.2	83.4	87.7
9	Goa	100.0	88.9	90.2	103.4
10	Gujarat	100.0	100.8	90.4	84.8
11	Haryana	100.0	122.9	103.2	125.0
12	Himachal Pradesh	100.0	102.2	126.6	114.9
13	Jharkhand	100.0	97.3	54.7	48.3
14	Karnataka	100.0	104.1	108.6	119.6
15	Kerala	100.0	82.5	79.0	73.2
16	Madhya Pradesh	100.0	125.3	163.5	173.9
17	Maharashtra	100.0	106.9	102.5	96.6
18	Orissa	100.0	141.7	117.3	98.2
19	Pondicherry	100.0	73.8	99.6	123.1
20	Punjub	100.0	91.5	73.3	92.4
21	Rajasthan	100.0	126.5	135.8	123.1
22	Tamil Nadu	100.0	103.8	116.4	105.2
23	Uttar Pradesh	100.0	111.7	114.7	128.0
24	Uttaranchal	100.0	134.8	162.5	146.6
25	West Bengal	100.0	74.2	72.0	70.9
Total of Major States		100.0	104.8	99.8	98.3
Total Industrialised States*		100.0	104.3	100.9	94.8
All India		100.0	104.8	99.9	98.4

* Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu.

The state-wise analysis of TFP indices depicts different pictures for different states. TFPI recorded a steady growth in Andhra Pradesh, Karnataka, Madhya Pradesh and Uttar Pradesh. On the other hand the TFPI recorded a declining trend in Assam, Chandigarh, Dadra and Nagar Haveli, Jharkhand, Kerala and West Bengal. In the remaining states and Union Territories the TFPI experienced considerable oscillations during the 1998-02 period (Table 4c). Table-4c also states that the TFPI increased in 1999-00 in Gujarat, Maharashtra and Orissa while in the subsequent years the TFPI recorded a decline in these states.

Industry-wise TFP comparison with the industries average for the year 2001-02 states that the TFP was lower in the agriculture and hunting-related services; other mining and quarrying; food products and beverages; textiles; wearing apparel, dressing and dying of fur; leather and leather products; wood and wood products; paper and paper products; other non-metallic mineral products; basic metals and manufacturing of furniture. In the remaining industries, except publishing, printing and reproduction of recorded media, the TFP was higher than the all industries average. TFP was highest in the manufacturing of coke, refined petroleum products and nuclear fuels industry and lowest in the recycling industry. The concentration of industrial activities and TFP of respective industries in each state and Union Territory have influenced the overall TFP in the concerned states and Union Territories.

Conclusion

The performance of industrial activities vary significantly across the states in India. It is well known that there is a direct linkage between infrastructural development and the growth and performance of the industrial activities. But, the provision of infrastructural facilities alone is not sufficient to improve the performance of the industrial sector. It appears that undue emphasis on capital-intensity has adversely affected the capital productivity. The organised manufacturing sector also saw restructuring in terms of size, due to which the the number of very large units declined and number of the middle and small-sized units increased. As a consequence average employment in the ASI factory sector units declined significantly.

Substantial fluctuations in the PFP_K and PFP_L across the states and different industry groups has had a neutralizing effect on the TFP in Indian manufacturing in the post-reform period. However, this does not mean that reforms failed to have a favourable effect on industrial productivity. There are various other factors which directly or indirectly affect

the productivity. To understand the impact of various factors on the industrial productivity, micro-level investigation is required.

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If man is to survive, he will have learned to take a delight in the essential differences between men and between cultures. He will learn that differences in ideas and attitudes are a delight, part of life's exciting variety, not something to fear.

– Gene Roddenberry

Feature

Growth Patterns, Productivity Behaviour and Technological Change in the Manufacturing Sector of Punjab

Rakesh Kumar

This study, based on the single and two-digit data from the ASI state level data for the period of 1980-2001, revealed that the manufacturing sector in Punjab has not experienced much change in its product mix pattern over time. The growth pattern of major variables was relatively better in the pre-reform period as compared to the post-reform period.

Rakesh Kumar is Lecturer in Economics, Punjabi University Regional Centre, Punjab.

This study has been carried out to study the production pattern, productivity behaviour and technological change in the manufacturing sector of Punjab. Economic theory states that the development pattern of any economic setup is dominated by the agricultural sector in the initial stages of its development and gradually when the process of growth starts rising, the manufacturing and service sectors attain the greater share (Kuznet, 1973). In addition, these sectors follow the specific pattern of growth, that is, composition of production also experience changes.

In this context, the Punjab state is also not an exception. In 1966-67, the agriculture sector had contributed 41 per cent of state domestic product, which has followed a decreasing trend and reached to 24 per cent in 1998-99; whereas the manufacturing sector improved its share from 8 per cent in 1966-67 to 21 per cent in 1998-99 (Punjab Development Report, 2002). No doubt, Punjab has enjoyed the fruits of the green revolution and had attained the highest level of per capita income. However, in most recent years, the state has failed to maintain its highest position in per-capita income and has lagged behind Goa, Maharashtra and Delhi Economic (Economic Survey, 2002-03). Moreover agriculture, which is the mainstay of the state economy, has been experiencing stagnation, as it has recorded negligible growth during the last decade (Singh, L and Singh, S., 2002). The cropping pattern of the state is dominated by wheat-paddy rotation and seems to be unsustainable due to increasing costs, irrigation and environmental problems (Johl, 2005, Aulakh, 2005). Attempts made by the government to change this cropping pattern in favour of new and commercial crops through contract farming could not bear fruit. Economic growth, which the state is experiencing, is less than the national average and failed to generate enough employment for the continuous rising size of job seekers. The

state has generated large number of technocrats through its technical institutions and the state's existing development pattern is unable to absorb the increasing educated unemployed.

Under such circumstances, the development of the manufacturing sector can provide some respite to the already dwindling economy of Punjab to regain its past glory. Punjab contributes less than 4 per cent to the total manufacturing output of India. In addition, after recording a trend growth rate of 2.2 per cent per annum in the pre-reform period, its growth in the manufacturing share of India has deceleratered to 2.1 per cent per annum in the post-reform period (Table 1). Thus, it seems that opportunities provided by new policy regime after 1991 could not be largely grabbed by the state. So when agriculture had reached its plateau, development of the manufacturing sector was the only way out to develop the state on modern lines. An attempt has been made in this paper to estimate the productivity levels and technological change in the manufacturing sector of Punjab.

Table 1: Share of Industrial Output of Punjab in the Industrial Output of India

Year	Percentage Share
1980-81	4.08
1985-86	4.30
1990-91	4.60
1995-96	4.00
2000-01	3.80
TGR	**Average Annual**
1980-81 to 2000-01	0.10
1980-81 to 1990-91	2.20
1991-92to 2000-01	-2.10

TGR stands for Trend Growth Rate

Methodology, Database and Variables

This study has been carried out to estimate the growth patterns of inputs and output variables, product mix patterns, productivity behaviour and input-output relationships of the Punjab manufacturing sector. For this purpose, various ratios, percentages, statistical and econometric techniques have been used. The share of Punjab industrial sector in the entire industrial sector has been calculated by dividing the price-adjusted industrial output of Punjab by the price adjusted output of entire India. Change in product mix patterns over time in the Punjab manufacturing sector has been estimated by calculating the percentage share of each individual manufacturing group (two-digit) in the total manufacturing output of Punjab. Trend growth rates have been calculated by using the **semi-log linear regression** analysis to see the change in growth patterns of various output and input variables in the entire manufacturing sector of Punjab and its two digit components.

Growth in productivity increases the capability of the system to produce more and controls the cost of production. For this purpose, **Total Factor Productivity Index** of productivity measurement has been used and calculated for entire manufacturing sector and its components groups. Under three input framework, Translog Index has been estimated by the following equation:

$$\Delta\log TFP_t = \Delta\log Q_t - [(S_{L(t)} + S_{L(t-1))/2 \times \Delta\log L(t)}] - [(S_{k(t)} + S_{k(t-1)})/2 \times \Delta\log K_{(t)}] - [(S_{m(t)} + S_{m(t-1)})/2 \times \Delta\log M_{(t)}]$$

In this equation, Q denotes value of output, L labour, K capital, and M material input and

$$\Delta\log Q_t = \log Q_{(t)} - \log Q_{(t-1)};$$

$$\Delta\log L_{(t)} = \log L_{(t)} - \log L_{(t-1)}$$

$$\Delta\log K_{(t)} = \log K_{(t)} - \log K_{(t-1)};$$

$$\log M_{(t)} = \log M_{(t)} - \log M_{(t-1)}$$

In this equation, S_L, S_k and S_m are the income shares of labour, capital and material inputs and add up to unity. Dlog TFP_t is the rate of growth of TFP.

Using the above equation, the growth rates of TFP have been computed for each year. These have then been used to obtain an index of TFP in the following way. Let A denote the index of TFP. The index for the base year, A(0), is taken as 100. Then the index for subsequent years is computed using the following equation:

$$A_{(t+1)} = A_t\,(1 + \Delta\log TFP_t)$$

To measure the **input-output relationships** and have a feel of technical change in manufacturing sector of Punjab over time. **Translog Production Function** on the cross section and time series panel data for two-digit groups has been estimated by the Cochrane Orcutt technique of estimation. This technique has been used up to five iterations to take care of the problem of auto-correlation. Functional form of the model is as follows:

$$\text{LogQ}_{it} = \beta_0 + \beta_k \log K_{it} + \beta_L \log L_{it} + \beta_m \log M_{it} + \beta_t T_{it} + .5\beta_{kk} \log Kit * \log Kit + .5\beta_{LL} \log L_{it} * \log L_{it} + .5\beta_{mm} \log M_{it} * \log M_{it} + .5\beta_{tt} T_{it} T_{it} + \beta_{kL} \log Kit * \log L_{it}$$

$+ \beta_{km} \log K_{it} * \log M_{it} + \beta_{kt} \log K_{it} T_{it}$
$+ \beta_{Lm} \log Lit * \log Mit + \beta_{Lt} \log L_{it} T_{it} + \mu_{it}$

The subscript 'it' indicate the observation for 'i^{th}' manufacturing group and t^{th} year. T is a time trend included in the equation to allow the function to shift overtime and the shift is interpreted as technical change.

Period of study

This study covers the period of 1980-2001, during which Punjab had witnessed political instability, which is also considered as a restriction on the development. This study has also been divided in two phases, pre-reform period (before 1991) and post-reform period (after 1991) to capture the impact of policy regimes. In the first phase, the state had experienced insurgency, militancy and it was governed by President's rule. The succeeding period witnessed the new economic reforms at the national level and Punjab remained continuously under a democratically-elected government.

Data source and prices

Annual Survey of Industries, various issues of Statistical abstract of Punjab and the website www.circonindia.com are the major sources of detailed information on industrial characteristics such as value of output, value added, employment, capital assets, emoluments, material consumed, etc. This information is available at national and state level. State level information has helped to generate the manufacturing data for the entire manufacturing set up (single digit) and at the two-digit level manufacturing groups. The industrial classification has been changed in 1998 and it is impossible to make the discrete series directly. For this purpose a vigorous exercise has been done by going to the level of the three-digit level to make the matching series by either clubbing or splitting the existing classification. For making price corrections in the reported data on value of output, gross value added, and material consumed; wholesale price index for manufactured commodities has been used. Wholesale price index for transport and machinery has been used to adjust the data on fixed capital and for depreciation. Consumer price index has been used to deflate the emoluments and wages. Every deflator has 1993-94 as a base year.

Variables defined

Value of output: It is the aggregate market value of products manufactured for sale, work done for customers and sale value of goods sold in the same condition as purchased which is adjusted for the difference in stocks of semi-finished goods at the beginning and at the end of the survey year.

Value Added: Gross value added equals gross expected market value of output less the gross market value of inputs.

Labour Input: Labour is a service input in production process. Obviously, it should be measured in terms of labour hours actually used during the production process. Of the three types of labour statistics doled out of ASI, namely, man hours worked, number of workers, number of employees, the first two sets deal with only a section of labour input suppliers. The labour input is supplied by workers, who work on machines and the supporting staff that create the conducive environment for keeping machines in operation. The latter type of labour input is supplied in the form of supervisors, technicians, managers etc. These along with workers are counted in the third set, the number of employees. The third set appears to be nearest proxy of the conceptual input accordingly.

Capital Input: Capital input manifests itself in two forms: fixed and working. Fixed capital bears a technical positive relationship with output and productivity. It embodies technical change as well. This is taken as a measure of capital input. However, even fixed capital input is a gross measure of capital variable, for, it inadvertently assumes full capacity utilization; behaviour feature which is controlled by market conditions. Gross fixed assets are favoured instead of net fixed assets, as the reported figures on depreciation are not sufficiently representative of the true capital consumption. To make the capital variable finally usable, the perpetual inventory method (PIM) has been used by making a capital series from a benchmark.

Material consumed: the total delivered value of all items of raw materials, components, chemicals, packing materials and stores that actually entered into the production process of the factory during the accounting year. This also includes the cost of all materials used in the production of fixed assets including construction work for the factory's own use. It, however, excludes all intermediate products consumed during the accounting year.

Product Mix and Growth Patterns

Has the Punjab manufacturing sector registered any change in its product mix during the study period? Did the product mix pattern trigger the industrial growth in Punjab through backward and forward linkages? Theoretically, when an economic system grows, the share of capital goods and intermediate goods record

an increase and the share of consumer goods start declining (Hoffman 1958). Did this also happen in the manufacturing sector of Punjab? In 1980-81, approximately 94 per cent of total manufacturing sector in the state was dominated by food & beverages (26%), Textiles and wearing apparels (21%), basic metals (18.8%), machinery & equip. (10%), motor vehicles & other transport equipments (9.5%), and chemicals (8.5%). A careful perusal of data given in table 2 reveals that consumer goods industry groups dominate the Punjab manufacturing sector. Over time it did not register any significant change in product mix; even the new policy regime introduced in 1991 by union government could not put any new trend in it. The only discernible change is in the manufacturing groups of basic metals and chemicals. The share of basic metals reduced to 13 per cent in 2000-01 from 18.8 per cent in 1980-81 whereas chemical industries have increased its share to 11 per cent in 2000-01 from 8.5 per cent in 1980-81. Approximately half of the industrial output share come from food, beverages and textiles. Hence it can be inferred that the Punjab manufacturing sector failed to generate any considerable industrial linkages.

Table 2: Share of Individual Manufacturing Groups in Manufacturing Output of Punjab

(Percentage Figures)

Industrial Group	1980-81	1985-86	1990-91	1995-96	2000-01
Food, Beverages & Tobacco	26	27	25	25	26
Textiles & Wearing Apparels	21	21	22	22	19.5
Wood & Furniture	0.13	0.09	0.08	0.07	0.15
Paper, Paper Products, Publishing & Printing	0.50	1.70	2.00	2.60	2.30
Leather & Leather Products	0.40	0.53	0.40	0.50	1.30
Chemicals & Chemical Products	8.5	10.50	9.00	9.00	11.0
Rubber, Plastic, Petrol & Coal Products	1.8	3.00	3.30	3.70	3.20
Other Non-Metallic Products	0.14	0.34	0.19	0.70	1.20
Basic Metals	18.8	16.30	15.30	15.00	13.0
Fabricated Metal Products (Except Machinery & Equips.)	3.30	3.10	3.20	3.50	3.00
Machines, Equips., Office & Computing & Communication	10.00	7.00	8	9.00	8.00
Motor Vehicles & Other Transport Equips.	9.50	9.20	11.40	11.60	11.0
Medical Precision, Opticals, Watches & Clocks	0.10	0.10	0.10	0.13	.40

Table 3: Trend Growth Rates of Output and Value Added in Individual Manufacturing Groups

(average annual figures)

Industrial Group	Output			Value Added		
	1980-2001	1980-1990	1991-2000	1980-2001	1980-1990	1991-2001
Food, Beverages & Tobacco	6.40	10.00	6.90	8.90	12.00	6.40
Textiles & Wear- ing Apparels	6.30	9.20	3.00	7.40	13.10	3.00
Wood & Furniture	6.60	2.00	17.30	5.80	5.40	10.00
Paper, Paper Products, Publishing & Printing	12.6	24.10	6.00	12.20	29.10	-.70
Leather & Leather Products	13.3	11.10	21.30	14.80	19.40	13.20
Chemicals & Chemical Products	7.10	11.00	6.20	5.50	4.10	6.00
Rubber, Plastic, Petrol & Coal Products	9.80	16.20	5.50	12.00	13.80	11.00
Other Non-Metallic Products	18.0	16.00	26.50	13.00	14.60	12.00
Basic Metals	5.10	8.30	2.40	5.40	6.90	1.80
Fabricated Metal Products (Except Machinery & Equips.)	8.10	9.00	6.40	9.40	9.20	6.30
Machines, Equips., Office & Computing & Communication	7.90	9.60	4.90	8.00	8.40	7.40
Motor Vehicles & Other Transport Equips.	8.80	11.00	4.40	8.70	10.90	5.90
Medical Precision, Opticals, Watches & Clocks	10.2	9.60	12.00	13.90	31.80	13.00
All Manufacturing Sector	7.00	10.0		5.30	7.70	10.30

As the Punjab manufacturing sector contributes 24 per cent to the state domestic product (Punjab Development Report, 2002), hence, trend growth rate behaviour in output and gross value added may enable us to

Table 4: Trend Growth Rates of Capital Assets and Labour inputs In Individual Manufacturing Groups (average annual figures)

Variable	Manu. Group	Food, Beverages & Tobacco	Textiles & Wearing Apparels	Wood & Furniture	Paper, Paper Products, Publishing & Printing	Leather & Leather Products	Chemicals & Chemical Products	Rubber, Plastic, Petrol & Coal Products	Other Non-Metallic Products	Basic Metals	Fabricated Metal Products (Except Machinery & Equips.)	Machines, Equips., Office & Motor Vehicles & Other Transport Equips.	Motor Vehicles & Other Transport Equips.	Medical Precision, Opticals, Watches & Clocks	All Manufacturing Sector
Capital Assets	1980-2001	10.2	8.2	11.9	6.4	11.1	-.40	9.3	14.9	2.1	6.0	4.0	4.5	4.5	3.6
	1980-1990	6.0	6.0	8.1	3.8	-.50	-4.0	12.4	6.30	-0.2	-0.2	8.1	5.2	18.2	0.2
	1991-2001	21.0	8.4	33.0	12.8	21.1	-.20	10.0	40.0	1.0	9.6	2.1	-3.5	3.0	4.7
Employees	1980-2001	5.0	1.60	2.0	4.2	9.0	2.8	6.9	5.5	-.5	3.5	1.7	4.7	4.4	2.8
	1991-2001	6.1	4.7	-6.9	10.5	10	4.5	10.4	4.5	0.3	0.2	2.9	6.0	6.6	4.6
	1991-2001	4.0	-0.2	12.1	2.4	8.8	2.6	2.7	9.0	-1.6	4.0	0.5	-1.4	4.2	1.5
Emoluments	1980-2001	6.4	4.1	3.0	7.4	10.0	5.9	8.6	6.0	1.6	3.2	5.2	6.9	5.5	5.2
	1991-2001	9.5	7.9	-1.1	16.8	11.2	8.1	15.3	11.0	3.7	2.4	6.6	9.2	8.0	7.9
	1991-2001	5.5	-.40	8.2	2.7	8.4	3.6	2.3	8.8	-1.4	2.6	2.1	-1.4	5.9	2.5

determine the changes in structure of the industrial economy of the state. Table 3 reveals that the manufacturing sector of the economy performed significantly better during the 1980s as compared to 1990s in terms of value of output and gross value added. For instance, output grew at the trend growth rate of 10 per cent per-annum in pre-reform period that decelerated to 5.30 per cent per-annum in post-reform period. It is true for the value added variable also, after growing at the rate of 10.30 per cent in the pre-reform period, it declined to 5 per cent in the post-reform period. It exposes that momentum generated in the first period could not be sustained later. However, both the variables, value of output and gross value added followed the same pace.A careful perusal of the figures given in the table highlights that the manufacturing groups which dominates the scene in the Punjab manufacturing sector registered comparatively better performance in 1980s and slowed down in 1990s. This is almost true in both the variables (value of output and gross value added). Alternatively, many of the industrial groups that account for minor share have picked up in 1990s, which indicates a slight change in behaviour during post-reforms period albeit very slow.

Why is it that this output and value addition could not accelerate in the post-reform period? Capital formation and technological change are two factors that contribute in the growth of output. Therefore, either the production capacity could not pick up over time or factors of production could not reflect optimally in output. In this context, growth of capital assets are calculated here and the issue of technological change is explored in the next sections. Figures given in Table 4 disclose that capital assets growth had followed acceleration principal: As in the pre-reform period it was negligible (.2 per cent per annum) and it accelerated in the post reform period (4.7 per cent per annum). In post-reform period, highest growth in capital stocks was experienced in order by other non-metallic products (40%), wood & furniture (33%), leather (21.1%), food & beverages (21%), rubber, plastic & petroleum & coal (10%), fabricated metal products (9.6%), textiles and clothing apparels (8.4%). These figures show that growth in capital stock figures have picked up in the post-reform period, and it may reflect in the high level of growth in output in coming years. Restrictions of MFA under the WTO have been removed and the international market may provide immense opportunities to exports textile products.

Punjab has a large army of technocrats and skilled people that it is continuously producing

through its technical institutions. To take advantage of this skill intensive workforce and to absorb them in the state, the manufacturing sector should expand at a fast pace. Labour employed in the manufacturing sector of Punjab has grown at the average annual rate of 4.6 per cent per annum in the pre-reform period which decelerated to 1.5 per cent in the post-reform period (Table 4). However, this growth rate was substantially higher in terms of emoluments, which indicates that the Punjab manufacturing sector is paying higher wages to its skill intensive labour. Unlike the capital variable, employment and emoluments growth was substantially lower in the post-reform period as compared to the pre-reform period. Dominant industrial groups did not experience any employment growth in the post-reform period, and even the textiles and motor vehicles have registered a negative growth.

Productivity behaviour

Productivity is measured as output per-unit of inputs. To pick up, the level of output productivity should grow positively along with the expansion of capacity. To measure the productivity growth for the manufacturing sector of Punjab, the **translog index of total factor productivity** has been measured. The results are depicted in Table 5. During the study period, total factor productivity has recorded a trend growth rate of 1.6 per cent per annum for the entire manufacturing sector of Punjab. Interestingly, this growth rate was higher in the pre-reform period (2.1%) and reached to a negative (-.2%) in the post-reform period on the lines of national studies (Golder, B, 2003, Trivedi, P., 2000). So, either the market did not favour the Punjab manufacturing sector, and in the globalised competitive scenario it failed to fetch the higher prices, or it could not keep its costs low. Punjab had to depend on other states for raw material and other intermediate products for its chemical-based and metal-based industries. This forces them to bear additional transport costs. However, agro-based industries that have potential here to develop could not grow to their capacity, owing to the laxity of the government. Industry groups that dominated the manufacturing scene of Punjab have recorded significant negative growth in the post-reform period except for motor vehicles, basic metals and chemical groups. Textile industry that enjoyed the captive market from the erstwhile USSR could not pick up in the productivity growth in the post-reform period. In the pre-reform period, highest productivity growth was recorded by chemicals & chemical products (4.3%), paper & publishing (3.7%), motor vehicles and other transport equipments (3.5%) and leather (2.1%). Therefore, the entire picture reveals that Punjab manufacturing could not perform on the productivity front in the post-reform period. Deceleration in output in the post-reform period has its origin in slow capacity growth and failure to keep the momentum of productivity growth.

Table 5: Total Factor Productivity Growth in Individual Manufacturing Groups (1980-2001)

(Average annual figures)

Manufacturing Group	Total Factor Productivity Growth		
	1980-2001	1980-1990	1991-2001
Food, Beverages & Tobacco	-0.50	0.00	-2.0
Textiles & Wearing Apparels	-0.10	0.30	-0.5
Wood & Furniture	-1.40	-0.50	-2.80
Paper, Paper Products, Publishing & Printing	1.10	3.70	-1.60
Leather & Leather Products	-0.70	2.10	-2.0
Chemicals & Chemical Products	2.30	4.30	0.80
Rubber, Plastic, Petrol & Coal Products	0.20	0.20	0.25
Other Non-Metallic Products	-0.90	1.70	-4.50
Basic Metals	0.40	-0.20	1.10
Fabricated Metal Products (Except Machinery & Equips.)	0.30	0.60	0.20
Machines, Equips., Office & Computing & Communication	0.50	0.10	0.20
Motor Vehicles & Other Transport Equips.	2.60	3.50	2.30
Medical Precision, Opticals, Watches & Clocks	-2.60	-3.30	-10.0
Entire Manufacturing Sector	1.60	2.10	-0.2

Input-output behaviour and technological change

Has the Punjab manufacturing sector experienced any change in input-output behavior and technological change over time? For this the translog production function has been estimated. To keep the relationships away from the problem of auto-correlation the Cochrane-Orcutt technique of estimation has been used for the panel data of thirteen sub-groups at the two-digit level of industrial classification. In addition, fixed effect of industrial groups has been separated to have the actual feel of the parameters. Two models have been estimated; model-1 a simple model, and model-2 were

Table 6: Cochrane Orcutt Estimation of Translog Production Function for Fixed Effect Two Digit Panel Data of Punjab Manufacturing Sector (1980-2001)

Variable	Model-1	Model-2
Constant	1.005* (.338)	1.10* (.367)
Log K_{it}	0.49* (.118)	0.49* (.118)
Log L_{it}	0.35 (.28)	0.354* (.28)
Log M_{it}	-0.143 (.099)	0.197* (.0063)
T	0.019* (.006)	0.128* (.024)
0.5 Log $K_{it}2$	0.13* (.024)	0.168* (.063)
0.5 Log $L_{it}2$	0.169* (.063)	0.0012 (.0013)
0.5 Log $M_{it}2$	0.118* (.024)	0.387 (.023)
0.5 T^2	0.0001 (.0001)	.0012 (0013)
$LogK_{it}*LogL_{it}$	-.387* (.063)	0.387* (.0632)
$LogK_{it}*LogM_{it}$	-.013 (.050)	-0.0124 (.0505)
$LogK_{it}*T_{it}$	0.008* (.002)	.0086* (.002)
$LogL_{it}*T_{it}$	0.008* (.002)	0.008** (.004)
$LogM_{it}*T_{it}$	-.0182* (.004)	-.0182* (.003)
Dt	–	-0.0072 (0.158)
R^2	0.994	0.994
D.W.	1.93	1.94
Standard Error	0.063	0.643
N	286	286

Figures given in parentheses are standard errors
Significant at 1 per cent level of significance:
** significant at 5 level of significance
D.W. is Durban Watson statistics
D is a Categorical variable =1 for 1991-2001
=0 otherwise

used to estimate the impact of reforms on the significance of parameters on a time specific dummy.

The results of the models are presented in Table 6. R^2 value indicates that models are best fit as its value is close to one. Values of Durban Watson statistics reveal that problem of auto-correlation is taken care of and estimated parameters can be relied on without doubt. Highly significant value of co-efficient attached to time highlights the technological progress. However, the rate of change in technological change is insignificant (co-efficient of t^2 is insignificant). Positive significant parameters experienced by $Kit*t_{it}$ and $L_{it}*t_{it}$ respectively highlight the complimentarity of technology with capital and labour that further highlight the existence of technology embodied in labour and capital. It can be inferred here that the Punjab manufacturing sector has experienced both embodied and disembodied technological change. Negative significant co-efficient experienced by $K_{it}*L_{it}$ provides a scope for the substitution of labour by capital along with insignificant elasticity of labour with respect to output. This is a very disturbing result in view of the widespread unemployment in the state. In other words, the manufacturing sector of Punjab failed to absorb the skill intensive labour. Hence, results indicate, capital variable has gained importance, over time, as suggested by the significant co-efficients of 'log K' and 'log K^2'. As such, the Punjab manufacturing sector has worked under almost constant returns to scale.

To discern the impact of structural adjustment reforms introduced by the union government in 1991-92, a dummy variable has been introduced in the model for the post-reform period and the results are presented in the table in the form of model-2. Interestingly, the co-efficient attached to this variable turned out to be insignificant. And the introduction of the dummy variable did not disturb the explanatory power of the model and failed to change the significance of any of the variables involved. It can be concluded here that the Punjab manufacturing sector could not be affected directly by the reforms introduced.

Concluding Remarks and Policy Issues

Punjab's industrial sector contributes merely 4 per cent to the entire industrial output of India, which has recorded a trend growth rate of 2.2 per cent per annum in the pre-reform period and decelerated to negative value of 2.1 per cent per annum in the post-reform period. The Punjab manufacturing sector is dominated by the industrial groups of food and beverages, textiles and wearing apparels, basic metals, machinery and equipment, motor vehicles and chemicals and over time this product mix pattern did not experience much change. Contrary to expectations, this did not tilt towards capital goods industries.

Punjab's manufacturing sector performed significantly betters in the pre-reform period as compared to post-reform period in terms of value of

output and value addition. However, the variable of capital has experienced negligible growth in the pre-reform period. It picked up slowly in the post-reform period and is yet to be fully reflected in output variables. Unlike the capital variable, employment and emoluments variables growth was substantially lower in the post-reform period. Dominant industrial groups did not record any significant growth in employment in the post-reform period. Slow down in the manufacturing scene in the post-reform period finds its origin in the slow capacity growth and failure to improve the productivity growth. Dominant industrial groups have seen negative growth in productivity in the post-reform period.

During the study period, Punjab's manufacturing sector appears to be working under constant returns. It has experienced both embodied and disembodied technological change in the factors deployed. Technological change is also biased towards capital and employment elasticity of manufacturing sector is negligible. In addition, change in policy set up in 1991 could not put much impact on input-output behaviour and significance of various variables.

These concluding remarks import following policy suggestions:

- The State government should encourage the private sector including multinational corporations and non-residents Indians to invest and expand their production capacity here. For this purpose, the state should provide best quality infrastructure and basic services. This would help them to control their costs and enable them to improve their productivity levels.
- As the manufacturing sector has recorded negligible employment elasticity, the state should encourage agro-based industries which have greater potential to absorb the continuous increasing educated technical labour.

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Obstacles are those frightful things you see when you take your eyes off your goal.

– Henry Ford

Feature

Effectiveness and Productivity in a Continuous Product Line Manufacturing System using TPM

N. Anatharaman

This paper deals with a case carried out in an automotive rubber moulding process to illustrate how to employ Total Productive Maintenance (TPM) to improve line effectiveness systematically and continuously towards achieving world-class standard. The major losses (minor stoppage loss) in the product line (mixing unit) are identified and eliminated by means of implementing kaizens (improvements).

N. Anatharaman is Head of Dept. of Manufacturing Engineering, Annamalai University, Annamalai Nagar.

During the last decade of the twentieth century all multinational companies started thinking about their demand on a global platform. At this juncture, the Indian economy has not made adequate allowance for the Indian industries in respect of productivity, flexibility, and quality. As a sequel to this, the survival of many industries is at stake. In order to be stable in the global market, engineers and managers are under pressure to manufacture products of competent quality at a competitive cost.

In a manufacturing industry, maintenance is not expense; it's an investment in improved manufacturing (Sanjay Fluloria et. al, 2004). To be really competitive and effective, companies must apply the Total Productive Maintenance (TPM) technique and concentrate their efforts to eliminate the contributing losses. Its purpose is to create WCM facilities that ensure zero defects, zero breakdowns and zero accidents. The Total Productive Maintenance (TPM) paradigm, launched by Nakajima (1988) (father of TPM) is the 1980s, has provided a quantitative metric (Overall Equipment Effectiveness – O.E.E) for measuring the productivity of individual production equipment in a factory. Nakajima classified the losses which are reducing the effectiveness of the equipment into 6 major categories as in Table I. TPM activities focus on elimination of these "six major losses" (Laura Swanson, 2001 and Muthukumar et. al, 2001).

In Table 1 the first two losses are defined as time losses, which are used for calculating the availability of equipment in the line. The third and fourth losses are speed losses that measure the line performance efficiency of equipment. The last two losses are regarded as quality losses; these losses directly affect the line quality rate of the equipment. TPM aims to increase the effectiveness of existing equipment in a given situation, through the effort of minimizing input (improving and maintaining equipment at an optimum level to reduce its

Table 1: Major Losses Classifications

S.No.	JIPM classified (Major) Losses	Definition	Goal
1	Failure	Failure types include sporadic function stopping failures (time loss) and function-reduction failures in which the function of the equipment drops below the normal level (quantity loss)	Zero
2	Setup and adjustment	Stoppage losses that accompany setup changeovers including adjustments for correct positioning.	Minimize
3	Minor stoppage and idling	Losses that occur when the equipment temporarily stops or idles due to sensor actuation or jamming of the work. The equipment will then operate normally through simple measures (removal of the work and resetting)	Zero
4	Reduced speed	Losses due to actual operating speed falling below the designed speed of the equipment.	Zero
5	Defect/Rework in process	Losses due to defect and reworking of product. i.e., losses in quality caused by malfunctioning production equipment.	Zero
6	Reduced yield	Material losses due to differences in the weight of the input materials and the weight of the quality product output.	Minimize

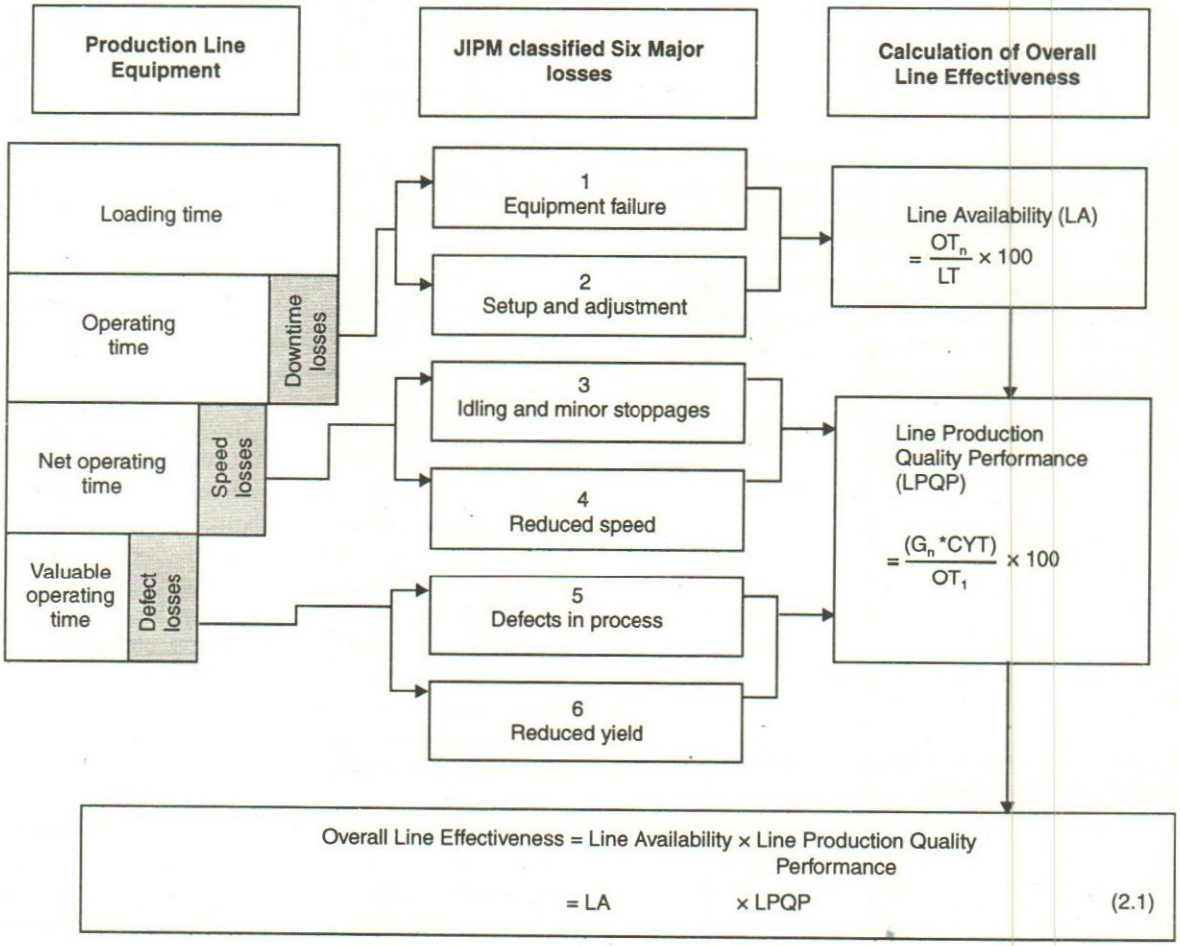


Fig. 1. Calculation of Overall Line Effectiveness (O.L.E)

life cycle cost) and the investment on human resources, which result in better hardware utilization.

The aim of this paper is to provide a conceptual framework of overall line effectiveness (O.L.E) measurement and the systematic continuous effectiveness improvement methodology in a product line manufacturing system.

Measurement of Overall Line Effectiveness (O.L.E)

Measurement is needed for identifying the problems and underlying improvement to increase productivity (Chandan Chouwdry, et. al, 1995). Value added to product line by a group of equipment is normally measured in terms of capability of performing or producing uninterrupted output. According to Nakajima (1988) the effectiveness of an individual equipment is measured as O.E.E (O.E.E = Equipment Availability X Equipment Production Performance X Equipment output quality rate). In a continuous line of equipment the effectiveness of the overall product line is measured using overall line effectiveness (O.L.E). TPM is aimed at maximizing overall line effectiveness. One hundred per cent effectiveness indicates that zero defects have been achieved and all the equipment in the line are working to full potential. The O.L.E is the product of two major parameters: Line Availability (LA) and Line Production Quality Performance (LPQP). The calculation of these two parameters and O.L.E are shown in Figure 1.

Where,

'i' Indicates the process ranges from 1 to n with respect to product flow/routing

'CT' Calender time of a shift/day/month

'PD_i' Planned down time of the concerned process. (The amount of time officially scheduled in the production plan. It includes down time for want of schedule, cleaning time and management planned activities – meetings)

'LT' Planned time available in first process of the production line.

$$LT = CT - PD_1$$

'DT_i' Down time of the concerned process i.e., the total time during which the system is not operating because of equipment failure, set up and adjustment requirements, exchange of dies.

'OT_i' Operation time of the concerned process. (The time during which the equipment is actually operating)

$$OT_i = [OT_{i-1} - PD_i] - DT_i,$$

OT_0 = CT (for the first machine in the product line the operating time is not affected by other machine)

'PRT_i' Performance reduction time of the concerned process i.e. the total time during which the performance of the system is reduced because of start up, less speed, minor stoppage and idling etc.

'CYT_i' Cycle time of the concerned process

'CYT' Largest process cycle time (CYT_i) among all the process in the product flow/line.

'N_i' Number of items possible to process in the concerned process.

$$N_i = \frac{OT_i - PRT_i}{CYT_i}$$

'n_i' Number of items actually produced in the product flow line.

'G_i' Number of good items produced in the line with respect to the concerned process.

For process - 1: $n_1 = N_1 = \frac{OT_1 - PRT_1}{CYT_1}$;

$n_0 = G_0 = D_0 = R_0 = 0$

For other process 'n_i' can be calculated as follows:

If $N_i \leq G_{i-1}$ then $n_i = N_i$, other wise $n_i = G_{i-1}$

'D_i' The number of items rejected or scrapped due to quality defects (listed by customer) with respect to the concerned process.

'R_i' Number of units produced in the concerned process need of rework or reprocessing to make it into acceptable (good) unit.

Now, O.L.E is calculated using the above equation (2.1) in Figure 1. If the individual process unit in the production line consists of more sub processes, then the effectiveness (O.L.E) is first calculated for the individual sub process unit and the overall line effectiveness (O.L.E) of the total product flow is measured.

The Problem

Overall line effectiveness (O.L.E) is used to measure the effectiveness of a combination of different machines and its losses across many dependent machines and its accessories in a product line. The literature survey indicates machines and its accessories in a product line. The literature survey indicates that at present there is no single, well defined, proven methodology for continuous systematic effectiveness improvement methodology for O.L.E in manufacturing organisation. The literature relate to a comparison of different maintenance strategies with TPM (Laura Swanson; 2001), implementation methodology '*survey*' (McKone et. al, 1999, 2001 and Kunal Kant, 2004) and '*case studies*' – (Suzuki, 1992, Jorge, 1997 and Bikash Bhadury, 2000) of TPM in different industries with respect to individual selected (model) equipment (Barve, et. al, 2004) only. Improvement made in specific model machine will not increase

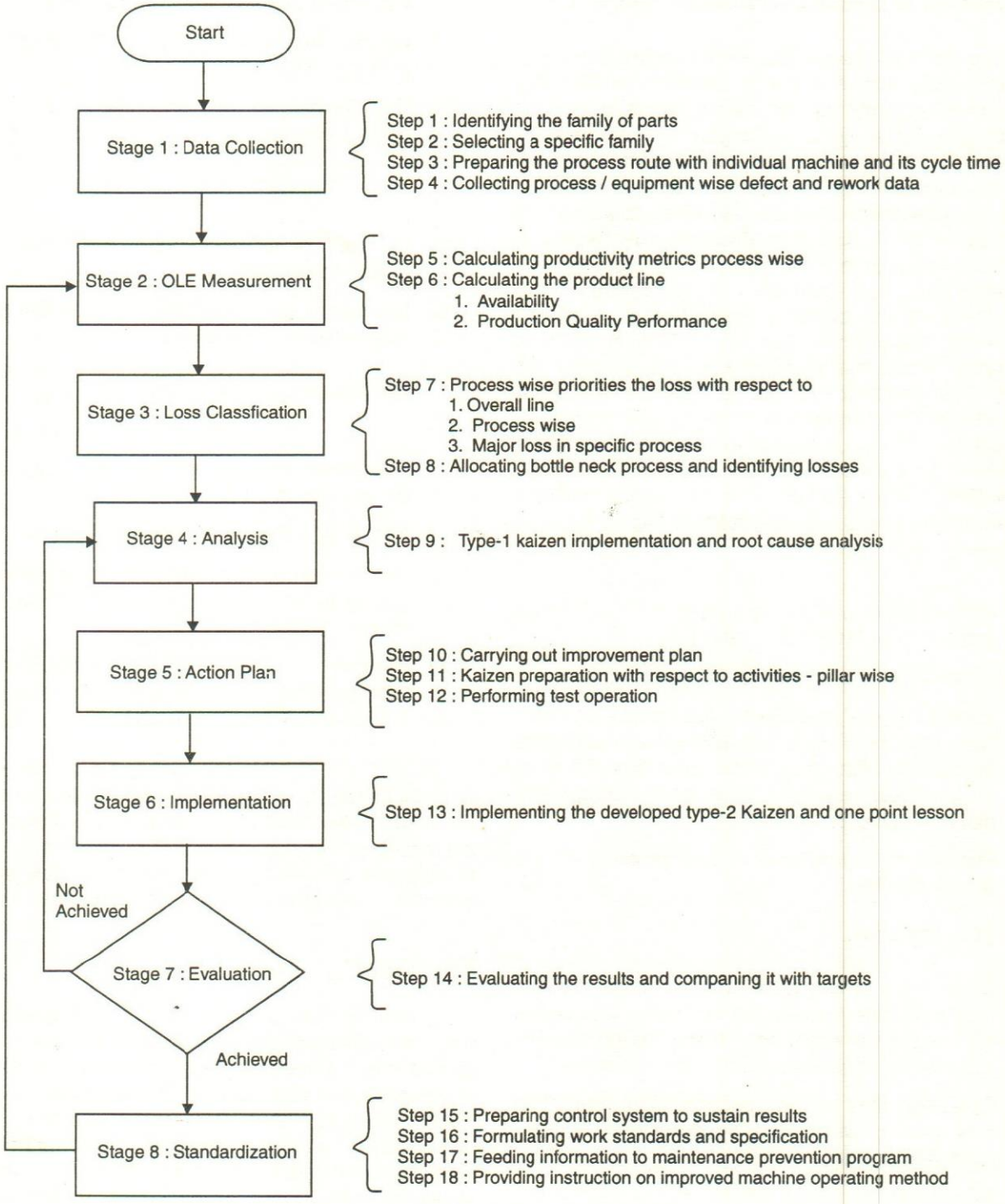


Fig. 2. Line Effectiveness improvement cycle

the effectiveness of overall product line and there is no scope for continuous improvement. So the continuous improvement methodology is developed in a step by step (user friendly) systematic process. By this engineers and managers in the organisation are addressing the specific losses in the bottleneck process and work towards continuous improvement in the line.

Proposed O.L.E Continuous Improvement Methodology

The 8-stage line effectiveness improvement method (Figure 2) is needed for achieving excellence in the manufacturing system. The proposed improvement method is a systematic process comprising 18 steps,

which are grouped into 8 stages of implementing the effectiveness improvement strategy.

The first stage is the basic stage of data collection. It includes the following four steps:

(i) *Identifying the family of parts:* Listing of all parts being manufacturing based on the basic commonality features, grouping it into the specific family. i.e., in a family of parts the basic combination of the processes and the sequence are the same.

(ii) *Selecting a specific family:* Selecting a specific family (type) of parts, which are categorized as high sales value and continuous market required (runner) items and possible to implement the improvements (kaizens). i.e., flow of products must be within the control of organisation (activities under one roof).

(iii) *Preparing a process route:* Preparing a process route chart for the selected family of parts and based on the route map, mark the operation and non-operation time (down time, planned down time) of each machine in the map.

(iv) *Defects and Rework data:* Based on the production log sheet report, collecting the defect and reworking items machinewise with respect to quantity processed on the selected family of parts.

The second stage, step 5, is calculating the productivity metrics (Loading time, Operating time) and other parameters necessary for LA, LPQP measurement processwise, and the step 6 is to calculate the overall line effectiveness (O.L.E) using the equation 2.1. The third stage, step 7, is calculating the reason (losses in Figure I) for O.L.E reduction and extending it to identify the specific and major contributing losses, and step 8 is fixing the bottleneck process and its contributing losses. In the fourth stage, general overview on activities carried over in product manufacturing about the time loss which are addressed directly (change in management policy) by work experience are done as type-1 kaizen and then (step 9) root cause analysis is carried out for determining the nature of the loss and its contributing parameters in detail with respect to the specific bottleneck process (identified in step 8). It includes at what frequency, when and why the abnormalities are occurring. The analysis can be done using different methods (Why–Why analysis, Physical Mechanism analysis (PMA), Fault tree analysis, Cause & Effect diagram) based on the nature of problem. A schematic representation of the improvement cycle is given in Figure 2.

In the fifth and sixth stage, step 10 to step 13 is preparing a plan of activities to be done with respect to the problem. The type-2 kaizen (improvement) can be developed by the concerned pillar and implementing it as per the plan. If necessary, the kaizen is tested in a model or run the production line for testing, and based on the results the kaizen is implemented in regular and continuous production line. The seventh stage, step 14, is to evaluate the kaizen, to see whether the identified losses is completely eliminated or minimized as per the plan in the specific bottleneck process. If not repeat it with stage 4, analysis. It indicates that the basic phenomenon (occurrence of the problem, source) is not identified exactly and it needs further analysis. If the results obtained are as per the plan (achievement of the target), then the process of simplification and standardization may be adopted. In the 8th stage, repeat the cycle by finding new bottleneck process and the concerned losses associated with it for continuous effectiveness improvement to achieve world-class status. Repeating the above 8 stage cycles results is one of the 2 different paths (loop in Figure 2) depending on the kaizens implemented. If the specific identified loss is not eliminated by the kaizens (type-1 & 2) taken, then the cycle may be repeated starting from stage 4. On the other hand, if the improvement introduces totally to eliminate the concerned loss in the specific process then the cycle should be repeated from stage 2.

Case Study

A real-world industrial case study was conducted using a production line from a leading rubber automotive components manufacturer in south India. As the rubber industry becomes more competitive, a company needs to reduce both production cost and produce a higher quality product. For this the company is interested to improve its capacity and capability of producing products as per the customer expectation using TPM techniques. The products manufactured in the

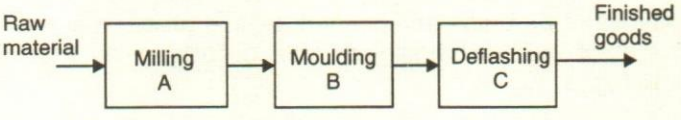


Fig. 3. Rubber parts manufacturing process flow

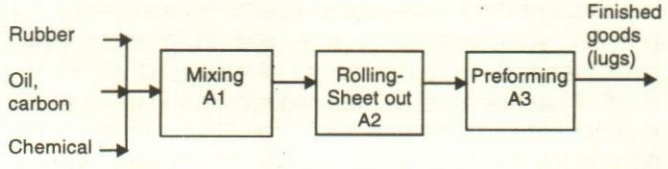


Fig. 4. Milling unit–product manufacturing process flow

Table 2: Snap shot of data input for OLE calculation – Milling unit (A)

O.L.E Parameters for Rubber Moulding process						
Data Entry Screen						
Unit:	**Milling**					
Date of study:						xx/xx/2004
Operator Skill level	Confirmed and 5 yrs Experience					
Number of process	Three					
Summary of data for	**A Shift,**					**Time: 8.30 to 4.30**
Process sequence	Mixing (A1)		Rolling (A2)		Preforming (A3)	
Operator token Number	AAA		BBB		CCC	
	Data Entry	Calculated Value	Data Entry	Calculated Value	Data Entry	Calculated Value
All entries of time in seconds						
Schedule meeting time 600	600		600		600	
Cleaning time	600		600		600	
Production Adjustment time (Not planned/No schedule/ Want of order)	0		600		0	
Planned Down time		1200		1800		1200
Breakdown time	1000		600		600	
Set up and adjustment time	500		600		600	
Down time		1500		1200		1200
Less speed time	2100		1800		700	
Idling and Minor stoppage time	3500		0		500	
Other Abnormalities time	1500		900		0	
Performance reduction time		7100		2700		1200
Idle cycle time/Item/Batch	12		10		12	
All entry's are in numbers						
No. of defectives/Item/Batch	25		10		2	
Rework items	40		15		0	

company are broadly classified as (i) pure rubber (ii) rubber with metal and (iii) rubber with fabric. For all the types of products, the general units in processing consist of milling, moulding and deflashing as shown in Fig. 3.

The Process

Each of the above process units includes many sub process with respect to the type of product being manufactured. Here the output of each unit will be the input of the next unit, (i.e. the product flow in a sequential manner between the units). The developed model is applied in the milling process unit (A). The general process flow within the milling unit is as shown in Figure 4.

In the Mixing process (A1), natural rubber is mixed in a kneader machine with chemical ingredients, oil and carbon to form a semi-solid cluster, which is then transferred to rolling process (A2) to form as a sheet with even thickness. The lugs are formed from the rolled rubber sheet by the Preforming process (A3). These lugs (specified shape with respect to the final product) are the output from the milling unit. Even though the general process in million is the same, based on the types of products being manufactured, the varieties and quantity of rubber, chemical, oil, carbon, and sheet out thickness (from rolling process) are varied. The operation time of Mixing, Rolling, Preforming is also varied with respect to the type of product.

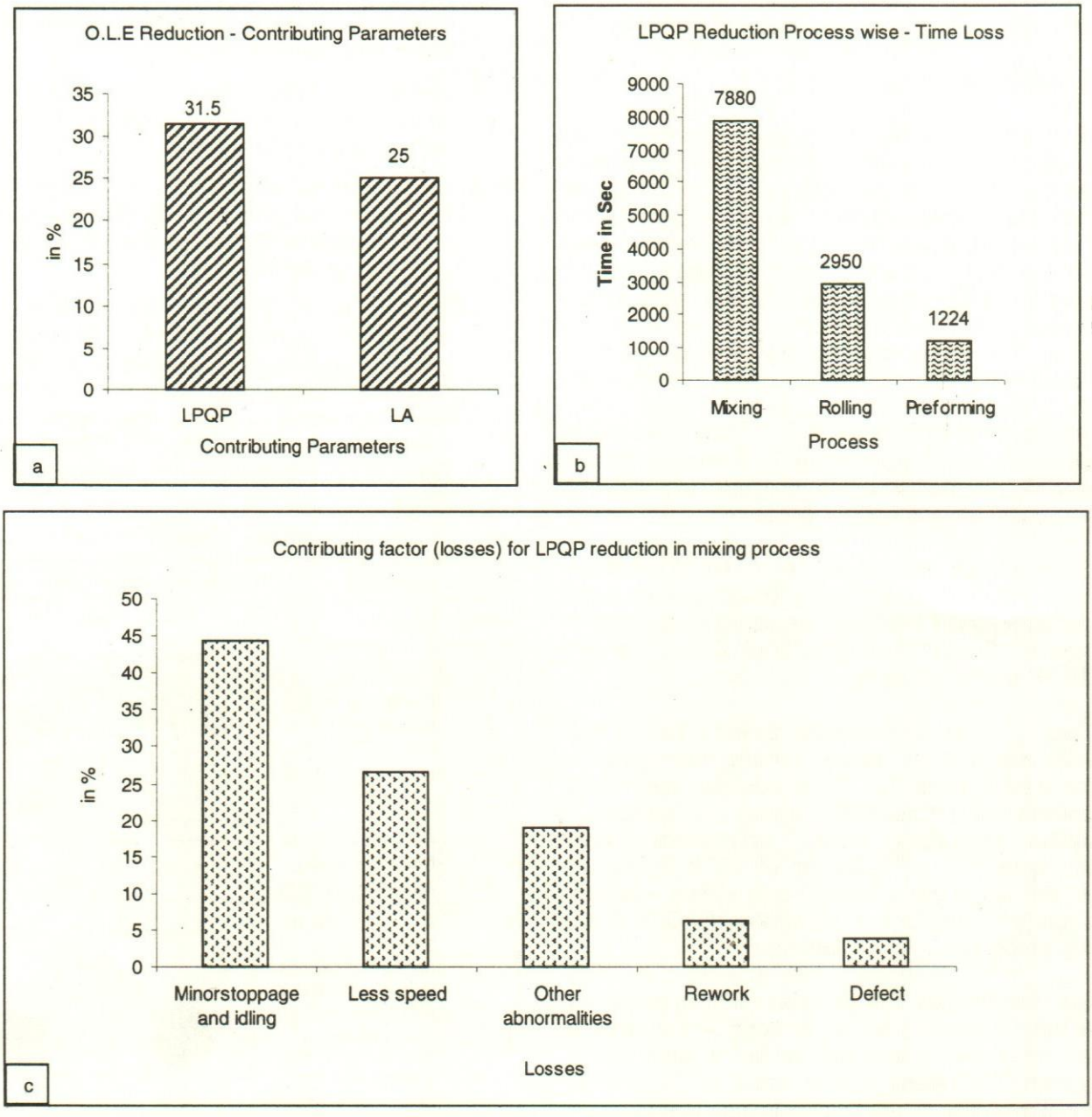


Fig. 5. O.L.E. Loss – Milling unit

The productivity of the Milling unit =

$$\frac{\text{(Number of lugs from Preforming process* Weight of each lug)}}{\text{Input weight of raw materials (chemical + rubber + oil + carbon) in Mixing process}}$$

Purpose of Implementation

The manufacturing score card analysis done by the management previously for non-achievement of productivity result shows that the productivity in the rubber moulding unit (B) is very low (i.e., more number of compression moulding machines are idle) due to non-availability of lugs in appropriate time from its parent process of Million unit (A). The production line is not smooth and control measures and not effective and the counter measures taken will not completely solve the problem and needs a regular follow up with the previous process unit (Milling - A) to make up the production line production line smooth. Using the O.L.E measurement technique, the improvements (kaizens) carried out are instantanous (one time activity – solving of specific problem) and it is not a continuous and systematic process. This does not improve the overall product line effectiveness significantly and continuously towards achieving

world-class standards in the specific product line being manufactured.

Application Methodology

Stage 1: Data collection: Based on the production daily log sheet, the data is entered on the software developed. The entries are with respect to number of process and its flow sequence. For the milling unit (A) the three sub process (Mixing (A1), Rolling (A2), and Preforming (A3) data are entered completely on the software and it can be extended to all the process units in the product flow line. But for this case, the problem is more on the milling unit. So the data collection is restricted within the milling unit. The individual lug weight (output from Preforming process) is 24 grams and the weight of input material to the mixing process is 60 kilograms. The following data (in Table 2) is for part number XXXXX, manufactured completely in a shift of 8 hrs. i.e., calendar time (CT) = 28800 sec.

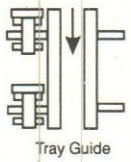
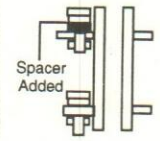
Stage 2: OLE calculation: The result of O.L.E calculation of the milling unit, using the above data in the developed software based on the equation 2.1 is 51.45 per cent and the contributing factor of LA, is 75 per cent and LPQP is 68.5 per cent.

Stage 3: Loss classification: Based on the output from the stage 2, the reason for the losses and its source are prioritized. The O.L.E reduction contributing parameters (LA, LPQP) for the milling unit is shown in Figure 5(a). Figure 5 (b) shows the bottleneck process as Mixing (A1) for the reduction of LPQP. Figure 5(c) shows the major contributing losses (Minor stoppage loss) on the contributing parameter (LPQP) in the 'mixing processes of milling unit'.

Stage 4: Analysis: The identified minor stoppage losses in the bottleneck process of mixing (A1) are easy to handle, liable to be overlooked and rarely recognized as a problem. The results of root cause of the problem (minor stoppage loss) that occurs in the mixing process of the milling unit which is identified using (Muthukumar et. al, 2001) Why-Why, PM and Fault tree analysis which is consolidated as below:

1. Mixing chamber doors are not 'closed/opened' during the loading and unloading of materials from the machine, which results in the increased cycle time of the concerned batch rather than the specified target cycle time.
2. The timings set by the operator on the sensors do not work effectively. The timings are not appropriately calculated i.e., sensor timings do not match with the standard timing. The available sensor is not appropriate to set the total cycle time at one stretch and there is a need of manual intervention at every addition of raw material in the mixing chamber.
3. The supply of raw material to the input chamber is not continuous. The material is struck and feeding stops intermittently.
4. Sensors are not working due to contamination of foreign material (carbon dust), which form a layer in between the contact portion of the sensors and body of the machine.
5. There is no weighment before loading of raw material in the mixing chamber. Depending on the raw materials (rubber) specific gravity, if the load supply to the rotor-mixing chamber is high it leads to tripping of motor, resulting in need of manual intervention to unload and load it again. There is no identification for attainment of high loads.

Table 3: Action plan for reduction of minor stoppage loss

Process: Mixing (A1)		Machine: Kneader	
Problem Number	Kaizen/ Improvements	Figure	
		Before	After
1	Fixing with lock washer and placing lock nut		
2	New high quality sensor be replaced		
3	R.P.M of wheel is altered and the number of cavities in rotating wheel is also increased. The diameter of each cavity in the rotating wheel is optimized based on raw material size		
4	Coverage of sensors (temporarily) from dust arrest the leakage from the source (Chamber lid by seals)		
5	Ammeter be fix on the input power supply and mark the colour coding in the dial of ammeter for the allowable load in mixing chamber		Ammeter with Green and Red mark Identification (Visual identification – In close to operator eye)

Stage 5: Action plan: The root causes of the problem summarized above are to be solved by adopting the following kaizens. The following Table 3 shows the plan of action (Kaizen list).

Stage 6: Implementation plan: It includes the stages of implementation based on the availability of resources, management approval and tested results from the model. We must consider the priority of equipment and accordingly plan the implementation sequence (not affecting the planned production time), simultaneously using this plan to track the implementation status, to see whether the activities carried over are as per the plan or not. By this the non-adherence of schedule is highlighted in every circle meeting and based on their importance it gets carried over to the next level.

State 7&8: Evaluation and Standardization: By implementing the kaizens as per the stages specified, no minor stoppage loss phenomenon occurs in mixing process of milling unit (down time due to minor stoppage and idling is zero), the observation has been made continuously for 15 shifts after implementing the 9 kaizens specified in Table I. And also standardized the operating procedure in kneader machine. Now the improvement cycles continue with state 2 (O.L.E calculation) and the contributing parameter (LA and LPQP), bottleneck process and losses are identified.

Results and Discussion

Line effectiveness is a comprehensive yard stick to measure and monitor the capability of the line to produce. By implementing type-1 kaizens (i.e., improvements done based on experience on overview of product flow), like:

(i) The circle meetings are made at one time for all the process in the product line, so the meeting is completed in the shift starting time itself. With this for the process of Rolling (A2) and Preforming (A3) the scheduled meeting time is zero (i.e., change in management policy about mingling of different process unit persons into one group meeting).

(ii) The cleaning time of Rolling (A2) and Preforming (A3) process are reduced by providing:

   a. Suitable cleaning equipment to clean the rubber sticks in-between the roller and guard gap. By this cleaning time in Rolling process is reduced from 600 sec to 300 sec per shift.

   b. Auto coolant sprayer with cover attachment in front die and cutting blade contact position. By this cleaning time in Preforming process is zero.

With this the overall planned down time of Rolling process (A2) is reduced from 1800 sec to 900 sec (PDT_2 = 900 sec) and the Preforming process (A3) is reduced from 120 sec to 0 sec (PDT_3 = 0 sec). After implementation of type-1 kaizen the line availability (LA) is improved from 75 per cent to 82.61 per cent, but the productivity of the milling unit i not increased. i.e., the real problem (in section 5.2) of productivity improvement in mixing unit (A) is not being solved.

By implementing type-2 kaizens (Table-I) based on the root cause analysis (stage - 4 of sec 5.3) the minor stoppage and idling loss in mixing process (A1) is reduced from 3500 to 0 sec and the performance reduction time (PRT_1) in the mixing process is reduced from 7100 to 3600 sec. The overall line effectiveness (O.L.E) has been improved drastically and the O.L.E before and after (type-1 and type-2) implementation of kaizens are as in Table 4.

Table 4: Comparison of results: Before and After Kaizen

S.No.	Parameter	Before Kaizen	After Kaizens		Overall Improvement in %
			Type-1	Type-2	
1	Line Availability (LA) in %	75.00	82.61	82.61	9.21
2	Line Production Quality Performance (LPQP) in %	68.55	68.55	81.97	16.37
3	Productivity of milling unit in %	59.64	59.64	71.32	16.37
4	Overall Line Effectiveness (O.L.E) in %	51.45	56.58	67.70	24.00

From the results (Table 4) there has been significant improvement (24%) in O.L.E (from 51.45% to 67.70%) due to improvement in contributing factor of LA and LPQP. Using type-2 kaizen (based on root cause analysis) the LPQP is improved by 16.37 per cent and the productivity of the mixing unit is improved by 16.37 per cent.

Conclusion

The O.L.E is the true index of continuous product line management. The effectiveness improvement of equipment in a product flow based manufacturing system is analyzed. The effectiveness improvement methodology proposed is validated with the case study in the rubber mixing (bottleneck) process and the major contributing loss (minor stoppage and idling loss) affecting the O.L.E are identified, analyzed and eliminated. The O.L.E of the milling unit is increased

from 51.45 per cent to 67.70 per cent. The productivity of the milling unit is also being improved by 16.37 per cent. The case study results show that the proposed improvement methodology is very effective in identifying the bottleneck problem and underlying improvements (continuously and systematically) to increase the effectiveness of product line in a specific time period. By these engineers' morale and confidence towards the improvement activities carried over are improved. Stronger machines with stronger systematic goal-oriented teams, results in a stronger organisation.

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Spoon feeding in the long run teaches us nothing but the shape of the spoon.

– E.M. Forster

Feature

Simulated Annealing Algorithm for Machine Loading Problem in FMS

K. Venkatasubbaiah & M. Anuradha

In this paper, a machine loading problem of a flexible manufacturing system (FMS) is discussed, with the bicriterion objectives of minimizing system unbalance (SU) and maximizing throughput (TH) in the presence of technological constraints such as available machine time and tool slots. A new perturbation method has been adopted to generate new sequences.

K Venkatasubbaiah and M Anuradha are faculty at the Dept. of Mechanical engineering, Andhra University,

The recent trend of production of a wide variety of end items and components in small batches using limited but versatile machines has resulted in several technological improvements in machine tools and has thus necessitated developments of efficient procedures for planning and control of production. Flexible manufacturing system (FMS) has recently emerged as a system with enormous potential for improvement in productivity. The aim of FMS is to achieve high volume mass production while retaining the flexibility of low volume job shop production. The decision making problems in FMS are divided into four stages, namely design, planning, scheduling and control.

The machine loading problem in FMS is considered as one of the most important planning problems. The machine loading problem in an FMS is specified so as to assign the machines, operations of the selected jobs, and the tools necessary to perform these operations by satisfying the technological constraints in order to ensure minimum system imbalance and maximum output.

The first mathematical formulation of FMS loading problem was given by Stecke (1983). A mixed integer formulation for the loading problem that includes balancing workload and meeting the due date of the job types was suggested by Shanker and Tzen (1985). Shanker and Srinivasulu (1989) developed a two-stage branch and backtrack procedure with the objective of maximizing the assigned workload. Mukhopadhyay et al. (1992) proposed a heuristic procedure for the loading problem where an essential ratio and max-max rule are used to minimize the system imbalance. Tiwari et al. (1997) developed a Petri net model for the loading problem. Vidhyarthi et al. (2001) proposed a fuzzy-based solution methodology to address the machine loading problem. Guerrero et.al. (1999) focused on the existence of alternative routes for each part type. The loading objective is to balance machine workloads.

Simulated Annealing

Simulated Annealing was first introduced in 1983 by Kirkpatrick as an intriguing technique for optimizing functions of many variables. Simulated Annealing draws its inspiration from physical annealing of solids, where a metal is brought to its lowest energy state by first heating it to a very high temperature and then cooling at a very slow rate, to a very low temperature. If the cooling is not slow enough, it may result in quenching, which is not desirable. It is a random search technique that is able to escape local optima using a probability function.

A generic Simulated Annealing algorithm is as follows:

1. Get an initial solution S.
2. Get an initial temperature $T > 0$
3. While not frozen, do:

- Perform the following loop n times
  - Pick a random neighbour S' of S
  - Let $\Delta = f(S') - f(S)$
  - if $\Delta < 0$ (downhill move) then $S = S'$
  - if $\Delta \geq 0$ (uphill move) then $S = S'$ with probability $P(\Delta, T)$
  - if $f(S) \geq f(S_{Best})$ then $S_{Best} = S$
- If $f(S) > f(S_{Best})$ then $S_{Best} = S$

4. S_{Best} is the best solution

Notations

H length of scheduling period (= 480 min)

Bi batch size of job i.

UT_j underutilized time on machine m

OT_j overutilized time on machine m

T_j tool slot capacity on machine m

t^r_{ij} time remaining on machine m after allocation of operation o of job j

t^a_{jm} time available on machine m after allocation of operation o of job j

t_{jmo} time required by machine m for operation o of job j

T^r_{jm} tool slot remaining on machine m after allocation of operation o of job j

T^a_{jm} tool slot available on machine m after allocation of operation o of job j

T_{jmo} tool slot required by machine m for operation o of job j

X_j, X_{jm}, X_{jmo} are the decision variable

Formulation of the problem

Given a set of jobs $j = \{1, 2....p\}$

Set of machines $m = \{1, 2...q\}$

Set of operations $o = \{1,2....r\}$

The first objective is to minimize the system imbalance:

$$\text{Minimize system imbalance } F_1 = \sum_{m=1}^{P} (UT_m - OT_m)$$

This is equivalent to maximize system utilization

$$\text{maximize } F_1 = \frac{M^* H - \sum_{m=1}^{P} (UT_m) - OT_m)}{M^* H}$$

The second objective is maximizing output or equivalently, maximizing the system efficiency. Hence the second objective is

$$\text{maximize } F_2 = \frac{\sum_{j=1}^{q} B_j * x_j}{\sum_{j=1}^{q} B_j}$$

Thus the overall objective function is

$$\text{maximize } F = F_1 * \frac{M^* H - \sum_{m=1}^{P} (UT_m) - OT_m)}{M^* H} + F_2 * \frac{\sum_{j=1}^{q} B_j * x_j}{\sum_{j=1}^{q} B_j}$$

Subject to the following constraints:

$$\sum_{m=1}^{q} (UT_m - OT_m) \geq 0 \qquad ...(1)$$

$$\sum_{K=1}^{P_i} T_{jm0} x_{jm0} \leq T^a_{jm} \qquad ...(2)$$

$$\sum_{j \in Z_{ik}} X_{mn0} \leq 1 \quad \ldots(3)$$

$$\sum_{m=1}^{q} \sum_{0=1}^{r_i} x_{jm0} = x_j * r_j \quad \ldots(4)$$

Where condition (1) ensures that the value of system unbalance must be either zero or a positive value. Condition (2) guarantees that the number of slots needed for the operation on a machine must be less than or equal to the tool slots available in that machine. Condition (3) and (4) represents the unique job routing and non-splitting of jobs respectively.

Methodology

Step 1

Initialize the model by specifying the control parameter (T), number of iterations for each level of T (Nmax) and stopping criteria (Tmin). The initial feasible solution for the problem is generated using the shortest processing time job sequencing rule (SPT). The initial solution becomes the first 'current' solution and the first 'best' solution used for the search technique. Calculate the objective function value for this initial solution. The objective function value for the current solution will be referred to as Ec, and the objective function value for the best solution will be referred to as E_b.

Step 2

From the current solution, generate a feasible neighbouring solution. This is done be new perturbation method.

Step 3

Calculate the difference between the objective function values of the test solution and the current solution. This difference will be referred to as the 'energy change' and is calculated from the formula: $\Delta E = E_t - E_c$

If the value of the energy change is positive ($E_c < E_t$) proceed to step 4 otherwise, proceed to step 5.

Step 4

If the objective function value of the new current solution (E_c) is more than the best solution (E_b), then the best solution is replaced by the new current solution. Proceed to step 6.

Step 5

Generate the metropolis criterion for accepting a test solution with an objective function inferior to that of the current solution. This criterion provides the following probability of an inferior test solution being accepted as the current solution.

$$P(a) = \exp(-\delta E/T)$$

Next, a uniformly distributed random number (Ran) from the interval (0,1) is generated. If the value of Ran is less than the probability of the inferior test solution being accepted as the current solution, hence the test solution is accepted as the current solution, proceed to step 6.

Step 6

If the current iteration number (i) is equal to the maximum number of iterations (Nmax) go to step 8. Otherwise increment the iteration number (i) by 1 and go to step 7.

Step 7

Adjust the cooling temperature by using the following relationship:

$$T = \frac{T_0}{1 + \ln i}$$

If the new value T is less than stopping criteria (Tmin) then proceed to step 8. Otherwise return to step 2.

Step 8

The simulated annealing heuristic is complete. The best solution is that corresponding to E_b.

Numerical Example

Now we present a numerical example, illustrating the application of the proposed Simulated Algorithm. The description of the problem is shown in table 1.

Step 1

Evaluate the initial solution and assign it to S

S = {1,4,5,6,3,2,7,8}

SU(S) = 76; TH(S) = 42; F(S) = 0.7427 ;

UA(S) = {3,7,8};AS(S) = {1,4,5,6,2}

Table 1: Description of the problem

Job Number	Operation Number	Batch Size	Unit Processing time (min)	Machine number	Tool Slot needed
1	1	8	18	3	1
2	1	9	25	1, 4	1
	2		24	4	1
	3		22	2	1
3	1	13	26	4, 1	2
			11	3	3
4	1	6	14	3	1
	2		19	4	1
5	1	9	22	2, 3	2
	2		25	2	1
6	1	10	16	4	1
	2		7	4, 2, 3	1
	3		21	2, 1	1
7	1	12	19	3, 2, 4	1
	2		13	2, 3, 1	1
	3		23	4	3
8	1	13	25	1, 2, 3	1
	2		7	2, 1	1
	3		24	1	3

Step 2

Assign the obtained initial feasible solution to the best solution (S_b) and the current solution (S_c).

$S_b = S_c = SU = \{1,4,5,6,3,2,7,8\}$

$i = 1, T_0 = 200$, Reject = 0;

Step 3

Generate (S_p, S).

Step 4

The selected sequence $S_p = \{1,4,5,6,3,7,2,8\}$;

$SU(S_p) = 55$; $TH(S_p) = 45$; $UA(S_p) = 2,3,8$

$AS(S_p) = \{1,4,5,6,7\}$; $F(S_p) = 0.7669$

Step 5

$\Delta S = F(S_p) - F(S) = 0.0242$

Step 6

$\Delta S > 0$

Go to Step 7

Step 7

Assign $S_p = S$

Step 8

$\Delta S_b = F(S_p) - F(S_b) = 0.0242$

since $\Delta S_b > 0$ Goto Step 9 else go to metropolis criteria

Step 9

Assign $S_b = S_p$

Step 12

Reject = 0

Go to step 13

Step 13

$i = i + 1 = 1 + 1 = 2$

$i < 14$

$$T = \frac{T_0}{1 + \ln i} = \frac{200}{1 + \ln i}$$

Go to Step 3

Step 3

Perturb $S \rightarrow S_p$

$S_p = \{8,4,5,7,3,2,6,1\}$

$SU(S_p) = 131$; $TH(S_p) = 38$

$F(S_p) = 0.7034$; $UA(S_p) = \{1,2,3,7\}$

Step 4

$\Delta S = F(S_p) - F(S) = -0.0635$

Step 5

$\Delta S < 0$

Go to Step 10

Step 10

$P = e^{-\Delta S/T} = 0.997$

Generate a Random number between (0,1)

$R = 0.16$

$R < P$

Go to Step 11

Step 11

Assign $S_p = S$

Step 12

Reject $= 0$

Go to Step 13

Step 13

$i = i+1 = 3$

$i < 15$

$$T = \frac{T_0}{1 + \ln 3}$$

Go to Step 3

In similar way, Simulated Annealing algorithm is implemented on the given problem and the final result obtained after doing a number of iterations is

$S_b = \{1, 4, 7, 3, 5, 2, 6, 8\}$

$SU(S_b) = 14; TH(S_b) = 48; F(S_b) = 0.7964$

Results

Comparison of proposed heuristic with Shanker and Srinivasulu (1989), Mukhopadhyay et al. (1992) Tiwari et al. (1997) and N.K.Vidyarthi et al. (2001).

Table 2: Comparison of Results

Total Number of Tool Slots	Shanker et al.		Mukhopadhyay et al.		Tiwari et al.		N.K. Vidyarthi et al.		Proposed heuristic	
8	SU	TH	SU	TH	SU	TH	SU	TH	SU	TH
	253	39	122	42	76	42	127	44	14	48

Discussion

The performance of the algorithm is measured according to an objective function, which is minimization of system unbalance and maximization of throughput. The proposed algorithm runs with any random sequence of jobs as the initial solution, but it is observed that the search if started with some specific sequencing rule (SPT,LPT,etc) performs better. Results are obtained using the proposed Simulated Annealing algorithm and are compared with those of Shanker and Srinivasulu (1989), Mukhopadhyay (1992), Tiwari (1997) and Vidhyarthi (2001) and are summarized in Table 2. It is evident from Table 2 that the performance of the proposed algorithm offers better results than other existing methodologies.

Conclusion

The primary contribution of this paper is the development of a Simulated Annealing approach for the problem of allocating the sets of operations of the job to the machines so as to minimize the system imbalance and maximize the throughput while satisfying available machining time and tool slot constraints. From table 2 it is observed that the proposed heuristic offers better results. This work can be extended by considering a few more objective functions namely, minimization of path movements, tool changeovers, setup changeovers along with measures of flexibilities.

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Feature

Challenges and Opportunities of Global Supply Chain Management

S. Balan, Prem Vrat & Pradeep Kumar

To compare the degree of implementation of an ideal supply chain in various countries, a Supply Chain Management Index (SCMI) has been formulated in this paper, with the help of a questionnaire survey and analysis. The difference between the Supply Chain Management Index (SCMI) of underdeveloped, developing and developed nations with respect to the ideal SCMI has been evaluated by using the method of gap analysis. Various strategies have been suggested for different economies in the world for optimizing their supply chain network and improving their SCMI.

S. Balan is research scholar, Prem Vrat is director and Pradeep Kumar is professor, IIT, Roorkee.

Global competition is transforming the way products are produced and moved around the world. Globalization has brought a new structure in the business world called global supply chain, which is a network of factories and material sourcing on a worldwide basis. International value chains are a mechanism by which firms can achieve a competitive advantage of either low cost or differentiation through the processing activities performed and their corresponding linkages with suppliers and buyers (Klassen and Whybark, 1994).

These networks have to be carefully managed to improve quality and reduce cost as well as lead-time. It requires controlling the inbound, outbound and procurement functions, with a supporting information system. These activities, nodes and linkages of international value chain become spread out around the world and therefore these are essential to coordinate the operations carefully. The first step in improving the coordination is to identify the present scenario of the supply chain management practices across countries, challenges and opportunities and the salient factors that affect the performance of global supply chains.

The literature in supply chain management is quite extensive (Tan, 2001) and a number of articles deal with global supply chains.

This research was undertaken with the following scope of work.

- To know the current practices of supply chain management followed across countries by developing a Supply Chain Management Index (SCMI) to benchmark one country's performance against another.
- To find out the potential need for improvement that would increase the National Average of Supply Chain Management (NASCM) practices.
- To identify the challenge and opportunities of

supply chain of a company when they operate or tend to operate globally.

- To identify the major factors affecting the Global Supply Chain Management (GSCM)

The main emphasis of this research is exploratory. For the purpose of this study, from all over the world around 26 countries were selected to identify the present state of the SCM practices. These countries were selected randomly on the basis of their economic growth (GDP) in the global market. The selected countries were China, India, Japan, Thailand, Singapore and Indonesia (in Asia); Sweden, UK, Germany, France and Italy (in Europe); USA, Canada, Mexico and Caribbean (in North America); Brazil, Argentina, Venezuela, Peru and Uruguay (in South America); South Africa, Botswana, Kenya and Ethiopia (in Africa) and Australia.

The survey

A survey instrument in the form of a questionnaire was used based on the constructs described. The survey questionnaire was mailed to 425 target experts from industries, the academia and consulting organizations. For questions regarding the percentage of implementation of SCM concern, the respondents were asked to point out their responses using a five-point Likert scale and for the rest of the questions they were asked to select the salient factors and components among the listed things. Eventually, 44 usable responses were received with a response rate of 10.35%. Individuals who responded ranged among the senior level executives from companies (9.0%), faculty from Academia (77.3%) and chief consultants (13.6%) as shown in Fig. 1.

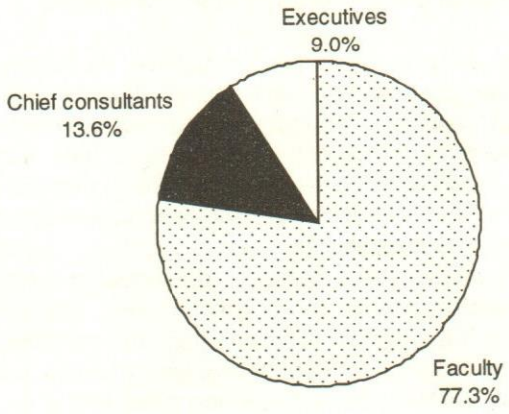

Fig. 1. Respondents categories

The respondents are comparatively better from Asia and constitute almost one-third (31.8%) of the total response, followed by North America (22.7%) and Europe (18.2%). The percentage of respondents for all the continents is given in Fig. 2.

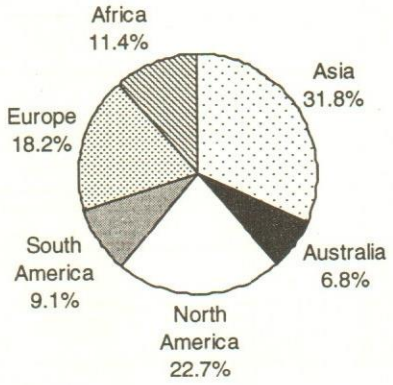

Fig. 2. Percentage of respondents by continental level

Analysis

The Supply Chain Management Index (SCMI) for all selected countries was developed from the feedback collected (Fig. 3). This figure has the Degree of development in X-axis and SCMI in Y-axis (both axes are drawn in a five-point Likert scale). A regression analysis was performed in order to measure the percentage of variation among data. The regression line of Y on X has been drawn with co-efficient of determination (R^2) = 0.7048 and it defines the proportion of variance in common between two variables (X & Y). From this R^2, the correlation coefficient value (R) was found out to be 83.95%. And it gives the quality of least squares fitting to the original data.

This analysis shows there exists a strong positive correlation between the two variables and the national average of SCMI can be improved by increasing the degree of development. Countries having SCMI-5 are ideal in nature and this is the target index to all countries irrespective of their present degree of development. Countries like the Caribbean and Indonesia are much closer to the margin of underdeveloped and developing stage with SCMI of 2.0 and 2.12 respectively. Similarly a degree of development of Singapore and Brazil are also close to the margin of developing and developed state with SCMI of 3.67 and 4.20 respectively. The SCMI of India and Italy is almost equal (2.55 & 2.61) but it differs in their degrees of development (2.08 & 3.5). The gap between the present SCMI to the ideal SCMI (5-point) is the focus of all countries. This gap is very large for Ethiopia (4.2) and very less for USA (0.3). In order to reduce the gap and improve the present SCMI, all countries need to look at potential areas for improvement.

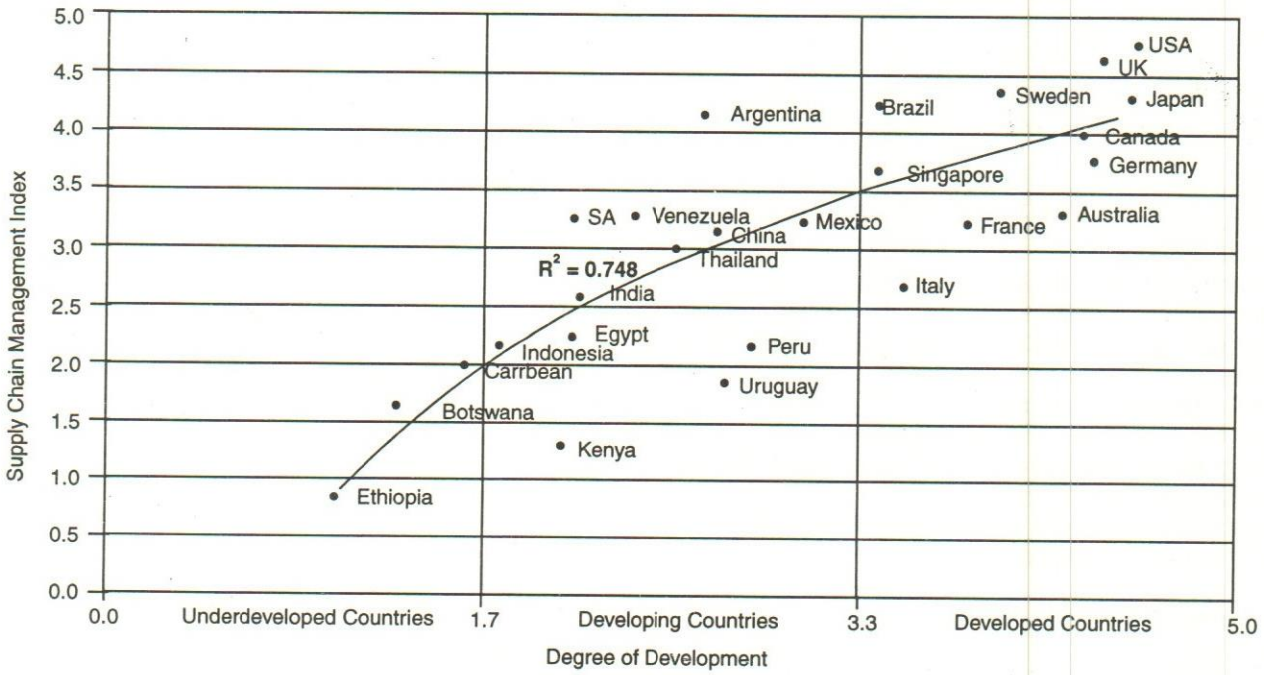

Fig. 3. Locations of countries on supply chain scale

The expert's feedback plotted in Figure 4 shows the potential practices that would increase the national average of SCM Indexes. These various potential practices have been ranked in the order of importance given by the respondents. However, there is no statistical difference at the significance level of these practices between the first and the last. All of the potential areas are of equal standing in the eyes of respondents. Even though the current utilization of supply chain planning and control tools and techniques is at a relatively moderate level, many of these tools and techniques are in their infancy (Jan Olhager and Erik Selldin, 2004). More interestingly the high awareness of Supply Chain Planning Tool and Techniques (SCPTT) (such as, Vendor Managed Inventory (VMI), Advance Planning & Scheduling (APS) and Collaborative, Planning, Forecasting & Replenishment (CPFR)), was preferred by more than 90% of the respondents. Currently many MNCs have invested in global electronic mail and ERP systems but have missed out on the international dimensions of supply chains. Recently, MNCs such as Welcome and P&G moved one step further to adopt CPFR principles in item promotions (Jonah Tyana and Hui-Ming, 2004). By implementing proper supply chain planning tools, e-business tools and IT enabled applications the national average of SCMI can be improved drastically. Most of the responses iterated the need of these practices.

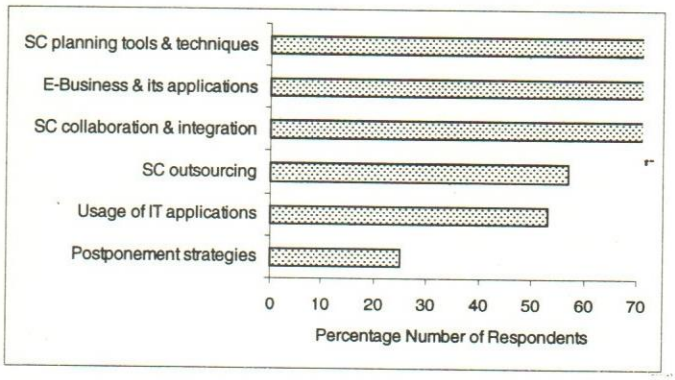

Fig. 4. Potential areas for improvement

The critical global supply chain challenges

For a company to be competitive, its supply chain must be cost-efficient responsive, flexible, agile and support customer requirements to receive the product they need in the quantity, in the right time and right place. Ensuring the presence of all these characteristics is difficult anywhere. But in Asia - a region of enormously diverse languages, cultures, currencies, regulations, taxes, infrastructures, business practices, organizational forms and economic-development levels, attempting to optimize the supply chain can seem almost futile. Complicating matters further, this diversity exists not only among countries, but also among cities within the same country in countries such as China and India.

The SCM concept is, however, nascent in India (Vrat, 1998). Increasing uncertainty of supply networks,

globalization of businesses, proliferation of product variety and shortening of product life cycles have forced Indian organizations to look beyond their four walls for collaboration with supply chain partners. On the other hand African countries are facing many critical challenges. Most of the African countries are in the margin of underdeveloped and developing stage. Expert's feedback from Africa shows that it undergoes a series of challenges like inferior logistics infrastructure, shortage of professionals, technological challenges and the present economy of the countries. Whereas the state of art technology, excellent infrastructure and availability of professionals and developed economy are the strength for the countries like USA, UK, Sweden, Singapore, Argentina and Germany (Michael Quayle, 2003). Hence the SCMI of these countries are relatively improved.

Among the list of challenges (Fig. 5), cultural mind-set and supply chain network complexity are perhaps the most challenging factors irrespective of the countries economical and geographical behaviours. Trust plays a major role in cultural mind-set and it is the foundation upon which information sharing and collaboration are built. Hence trust between supply chain partners plays a crucial role. Shortage of professionals is perhaps the least challenging factor for the developed economy (European and American countries), rather it is a crucial factor for the least developed economy (African countries). Poor infrastructure is almost an equally challenging factor for most of the Asian and African countries.

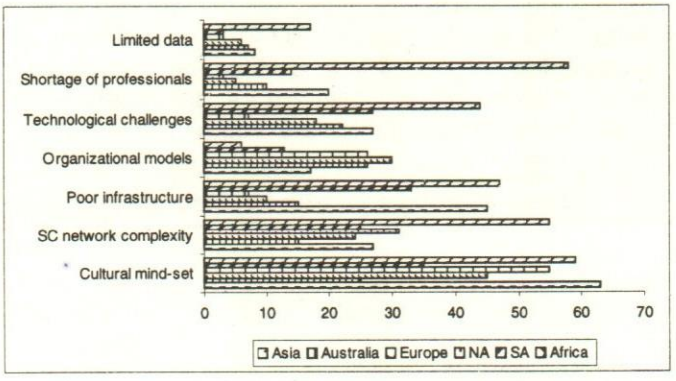

Fig. 5. Supply challenges of each continent

On the other hand, a misaligned supply chain and misaligned flow of information can distort shareholder value. For example, in Christmas 1994, there was a disaster for the mobile phone maker Motorola. Due to bad SCM, the company underestimated demand and ran out of mobile phones. Its distributors were fuming, and so were customers. Hence in Christmas 1995, Motorola decided not to repeat the mistakes of the previous year, and manufactured three times the stock. Again, Motorola did not communicate with their distributors, who over-ordered in anticipation of scarce stock. The result was the highest sales that Motorola had ever encountered. The stock market reacted and Motorola's share prices shot through the roof in that quarter. But in the next quarter, Motorola announced a huge drop in sales and profits as distributors were saddled with excess Christmas stock and the market supply readjusted itself. The mobile phone company's share price dived. From then onwards, investors saw Motorola as an unstable stock.

The weak links

The strength of the supply chain is determined by its weakest link. What are these weak links? How to identify them? When does a chain loose its strength? It is a great challenge for the managers to govern their flows from upstream to downstream. All supply chain challenges (including the floating challenges like labour strike, trust between suppliers, uncertain government, internet security etc,) may become a weak link when its impact on global chain reduces its strength. As an example, the 17-day labour strike in March, 1996 at the Delphi brake plant in Dayton resulted a big shut-down of 26 General Motors Corp. assembly plants and it affected nearly $1 billion in the company's first quarter earnings. It emphasized the importance of maintaining healthy labour relations (Fitzgerald and Craig, 1996).

Banks are crucial in the third element, since money flow is one of the vital parts in the supply chain. They are the enablers of payment, settlement, and providers of finance and trust. In order to have a smooth material and information flow, good understanding between the nodes of supply chain is must. But experts believe that this element is missing most of the time.

The global supply chain opportunities

With few exceptions, supply chains in Asia are more fragmented and less competitive than those in the United States and Europe. Depending on the country and the industry, supply chains in Asia lag three to five years behind the West in terms of creating efficiencies and improving effectiveness (David Pyke et al., 2000). Companies that do business in Asia need to aggressively work to close this performance gap and they need to look at the various opportunities. A golden opportunity to the present GSCM is the development of recent IT and communication and thereby it leads to integrate the technology and system architecture (Fig. 6). But companies in Asia often embark on multiple supply chain projects without a coherent guiding supply chain strategy (Richard Lamming, 2000). In fact, almost one-

third of companies in India have no supply chain strategy (Sahay et al., 2003). A more strategic SC approach leads to tax and duty optimization and better end-of-life product management, which can reduce inventory obsolescence.

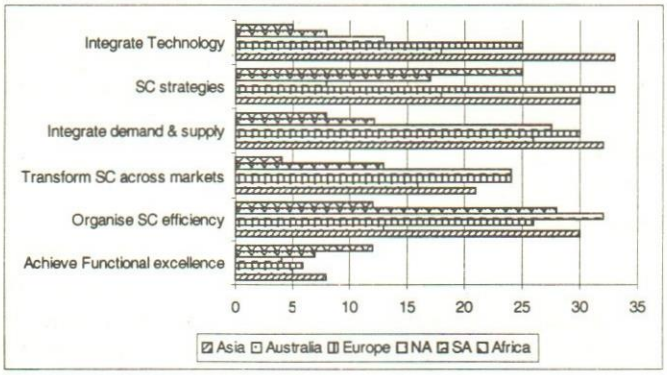

Fig. 6. Supply chain opportunities of each continent

This research shows that almost one-third of experts strongly believe in demand and supply integration across the enterprise. This can be seen in the case of the Toyota supply chain in Japan. The cost of variability in demand can be seen to be disproportionately higher in the UK than the negligible cost to the Toyota supply chain in Japan (Peter Hines, 1998). This variability of demand when it moves from downstream to upstream in a SC is called bullwhip effect. Effective integration of supply and demand is a cornerstone of supply chain success. It is intuitive that companies striving for supply chain competitiveness must first organize for efficiency. This means optimizing the whole and not its constituent parts.

Companies operating in European and American countries are shining in their functional excellence and technological competence. This acts as a great asset for them. Introduction of the Euro and free trade between selected European countries have added to the supply chain strength. With increased centralization and added transparency, Accenture Inc., sees significant rationalization opportunities and the emergence of supply chain shared service centres in Asia and Europe. Across Asia, major opportunities exist for industries and companies to collaborate with the objective of enhancing their joint supply chain efforts. Experience in the United States, Europe and Australia shows industry-level collaboration around data standards, protocol and pallet and container standards that can lead to significant savings and efficiency.

Factors influencing global supply chain management (GSCM)

The various factors affecting GSCM are geographical isolation, endowment factors, technology, arbitrage & leverage etc. Fig. 7 depicts the percentage of number of respondents versus the various factors. Among the list of factors, the cultural factor was shown as the most affecting factor of GSCM, with 91.6% favorable responses against it. Variations in cultural practices can cause errors in the communications between the various nodes in a supply chain (Murphy et al, 1989). Technology was considered as the second most critical factor next to cultural factors with 87.5% favorable reply. Multinationals are more likely to employ advanced technologies relative to their domestic counterparts (Sum and Yang, 1993). Moreover there needs to be a mechanism that allows for the flow of ideas, drawings and designs and technical reports among the various nodes. For example, if engineers in Brazil find a new way to reduce process variability, that information should be promptly accessible to engineers in France in spite of the language barriers. Geographical isolation of Japan and New Zealand greatly affects its local manufacturer to compete with global MNCs (Chuda Basnet et al., 2003).

Government officials have realized the importance of having their country as a part of various MNC's value chains (Sameer and Jayavel, 2003). Governments provide an array of incentives to multinationals so as to become a sourcing platform for them. Factors such as arbitrage & leverage (8%) and international markets (16.6%) were considered as least important by the respondents. Countries around the world have considerable differences among them and can offer opportunities to gain a competitive advantage. A country might be an attractive sourcing platform due to its endowment and financial factors (USA & UK). On the other hand it might be a critical challenging factor for economically underdeveloped countries (Ethiopia & Botswana).

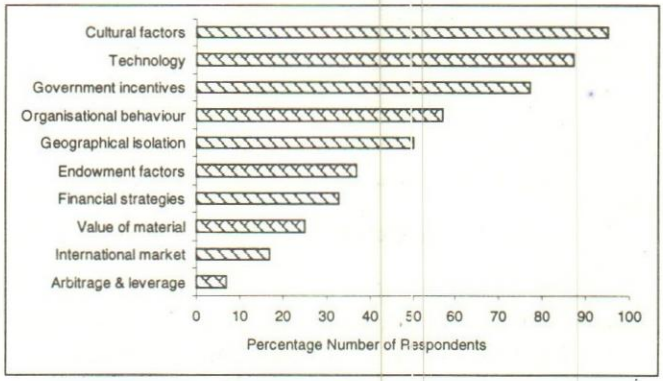

Fig. 7. Factors influencing Global Supply Chain management

Bullwhip effect

Bullwhip effect is defined as a phenomenon of in-

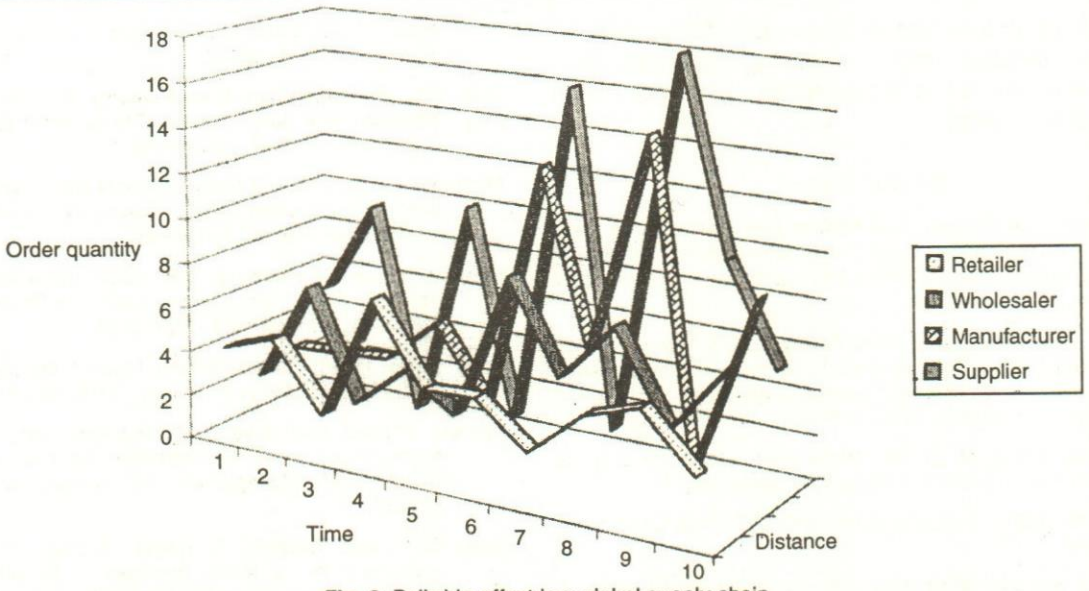

Fig. 8. Bullwhip effect in a global supply chain

crease in customer order when it moves from downstream to upstream in a supply chain. The term bullwhip is not a new concept. Though it was documented firstly by Forrester (1969), the name "bullwhip" or "whipsaw" was coined by Lee et al., (1997a & 1997b). According to Lee et al, a small variance in the demands of the downstream end-customer may cause dramatic variance in the upstream supplier's side. The globalization of supply chains leads to an increase in the time delays and the distances involved, and hence it further increases the bullwhip effect as shown in Fig. 8. For example, Hyundai's assembly plant is located in Chennai, India. Thousands of its spare parts are being brought from various countries and they are assembled in this plant and then the final quality tested cars are sent to European countries. A small amplification of the demand in its downstream side (Madrid) may cause amplified demand in its assembly plant (Chennai) and it may be further amplified when it goes to it design centre at Seoul.

Excessive inventory investments throughout the SC, poor customer service, lost revenue, variations in the logistic chain, missed production schedule and uncertainty in decision-making are the negative effects of the bullwhip effect. This effect can be reduced by implementing a good web-enabled information sharing, just-in-time replenishment, batch ordering, price stabilizing and shortage gaming.

Conclusion

Supply chain management is an integrated concept. To keep the supply chain competitive, the integrated supply chain network should be monitored continuously and adapted to a dynamic international environment. Information systems are vital to the coordination of supply chain activities. In this paper SCM indexes have been derived by a questionnaire survey and analysis and hence the strength of a list of selected countries has been identified. The sample size considered in this analysis was limited and the findings are tentative. This survey is able to provide an overview of the status of current SCMI and degree of development of selected countries. Hence increasing the sample size and number of countries across the world can extend this research. A detailed investigation considering the impact of the Bullwhip effect on the global supply chain management can also carry out further research. And more thorough investigations are required to increase the confidence interval of the current SCMI and the degree of developments of various countries. The research suggests that the SCMI of any country can be improved by implementing the following strategies subject to its own challenges and opportunities:

- Having proper supply chain planning tools and techniques
- Defining a supply chain strategy
- Using e-business and its application
- Harnessing the power of IT
- Having inter and intra-organizational integration
- Applying TQM principles in the supply chain from upstream to downstream.

These strategies would help the international managers to gain competitive advantages such as

lower cost of global supply chain operation and differentiation through the processing activities performed and their corresponding linkages with suppliers and buyers.

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I always read the last page of a book first so that if I die before I finish, I'll know how it turned out.

– Nora Ephron

Feature

An Interpretive Structural Modeling of Enabler Variables for Integration in SCM

V.C. Pandey, Suresh Garg & Ravi Shankar

Interpretive Structural Modeling (ISM) has been used in this paper as a methodology for identifying and summarizing relationships among specific integration enablers of a supply chain, which define an issue or problem. It provides a means by which order can be imposed on the complexity of such enablers and their relationships. In the present paper, key identified enablers (also referred to as variables) for the integration of the supply chain have been analyzed to obtain an ISM, which shows the inter-relationship of the variables and their levels.

V.C. Pandey is faculty at Maharaja Agrasen Institute of Technology, New Delhi; Suresh Garg is professor at Delhi College of Engineering, New Delhi and Ravi Shankar is faculty at IIT, Delhi.

A supply chain is a network of members formed by autonomous entities (and their systems) by bonding together to provide products and services to the satisfaction of customers at a minimum cost. With their collective and collaborative efforts, they sustain the progress of each member as well as of the group. Collaboration between members requires effective communication. In a collaborative environment, a member may modify its norms of behaviour to accommodate other members' perspectives (Simchi-Levi et al., 2000 and Chaib-Draa, 1996).

Increasing competition due to market globalization, product diversity and technological breakthroughs stimulates independent firms to collaborate in a supply chain that allows them to gain mutual benefits. This requires the collective know-how of the coordination mode, including the ability to synchronize interdependent processes, to integrate information systems and to cope with distributed learning.

Coordination among independent firms, such as raw-material suppliers, manufacturers, distributors, third-party logistics providers and retailers, is the key to attaining the flexibility necessary to enable them to progressively improve logistics processes in response to rapidly changing market conditions. Poor coordination among the chain members can cause dysfunctional operational performance. Some of the negative consequences of poor coordination include higher inventory costs; longer delivery times, higher transportation costs, higher levels of loss and damage, and lowered customer service (Lee et al., 1997). Since changes that occur in any one of the chain members are likely to affect the performance of the others, coordination is useful for managing interdependent logistic activities in order to mitigate demand variability and unnecessary inventory. A process of planning, executing and controlling the interdependencies of activities carried out by different supply chain members or business units in order to create value

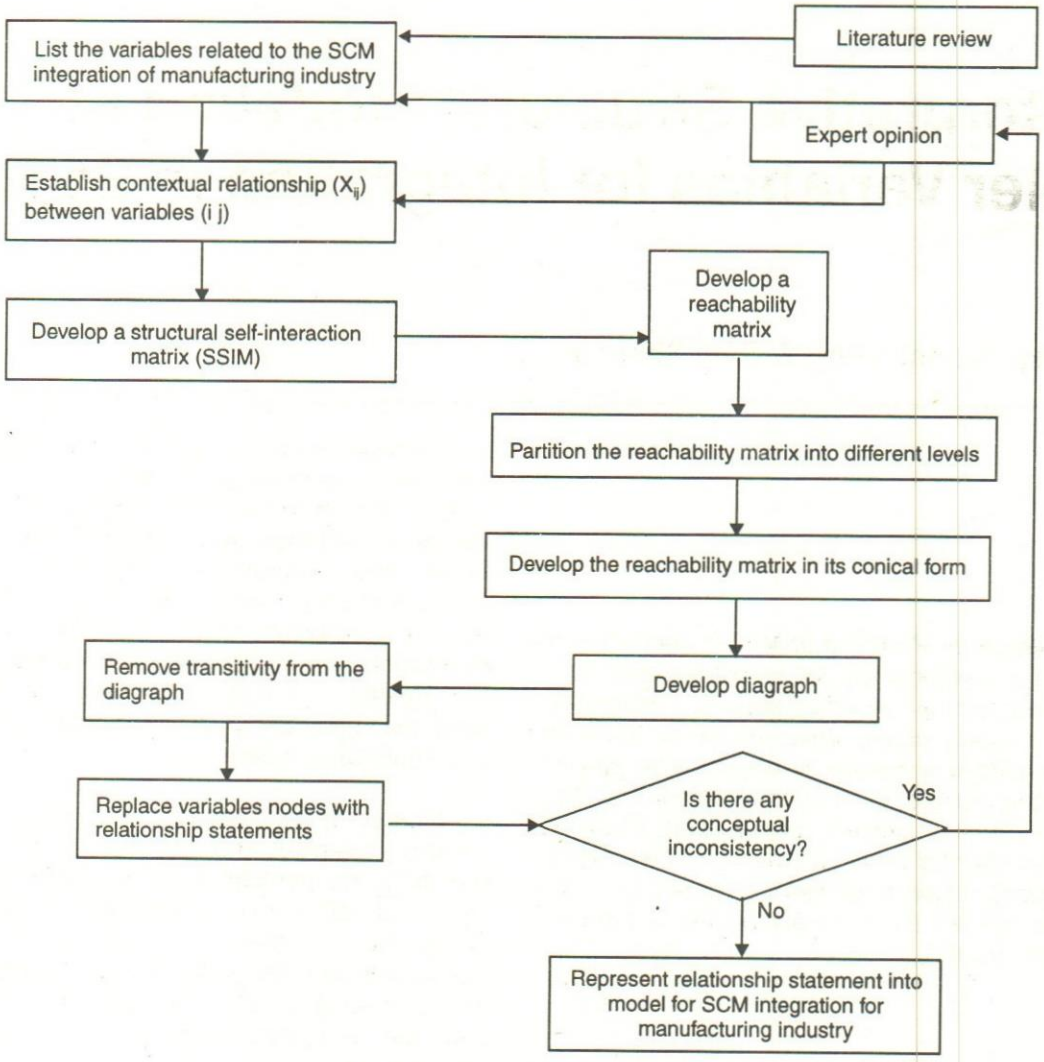

Fig. 1. Flow diagram for preparing IS

for the end customer, is known as supply chain management (Lambert et al., 1998).

Integration across the supply chain is achieved through synchronization of activities at the member entity and aggregating its impact through process, function, business, and on to enterprise levels, either at the member entity or the group entity. With integration, there will often be many direct connections between people at various decision levels across the interlinked firm in the supply chain. Technicians from the buyer will communicate directly with technicians of the supplier. Production planners at the supplier will be in close contact with purchasing personnel at the buyer (Bagchi and Larsen, 2003). Thus, by synchronization of supply-chain components, existing bottlenecks in the system at various levels are eliminated, while future ones are prevented from occurring.

Interpretive Structural Modeling (ISM)

ISM is an interactive learning process. A set of different and directly related elements are structured into a comprehensive systematic model. The model so formed portrays the structure of a complex issue or problem, a system or a field of study, in a carefully designed pattern implying graphics as well as words. ISM methodoology helps to impose order and direction on the complexity of relationships among elements of a system. Saxena et al. (1990) identifies the key variables using direct as well as indirect inter relationships amongst the variables and presents the results of the application of ISM methodology to the case of 'Energy conservation of in Indian Cement Industry'. To identify the key actors, objectives and activities for energy conservation in the Indian Cement Industry, ISM (Saxena et al. 1992) has been used to develop direct relationship matrices. Sharma et al. (1995) carry out ISM to develop a hierarchy of action

required to achieve the future objective of waste management in India. Some important vendor selection criteria have been analyzed (Mandel and Deshmukh, 1994) using an ISM that shows the inter-relationship of criteria and their levels. These criteria have been categorized depending upon their driving power and dependence.

The method is interpretive as the judgment of the group decides whether and how the variables are related. It is structural as on the basis of relationships an overall structure is extracted from the set of complex variables. It's modeling technique on the specific relationships and overall structure are portrayed in a diagraph model. ISM is primarily intended as a group learning process, but the individual can also use it.

ISM starts with an identification of element, which are relevant to the problem or issue and then extends to group problem-solving techniques. Then a contextually relevant subordinate relation is chosen. Having decided on the element set and the contextual relation, a structural self-interaction matrix (SSIM) is developed based on a pair-wise comparison of elements. In the next step, the SSIM is converted into a reachability matrix and its transitivity is checked. Once a transitivity embedding is complete a matrix model is obtained, then the partitioning of the elements and an extraction of the structural model called ISM is derived.

Steps in ISM

The various steps involved in the ISM technique are given below.

1. Variables are listed down, which can be Objectives, Actions, Individuals etc., and a contextual relationship is established among variables with respect to which pairs of the variable would be examined.
2. A Structural Self-Interaction Matrix (SSIM) is developed for variables of the system.
3. A reachability matrix is developed from the SSIM and is checked in the matrix for transitivity.
4. The reachability matrix is partitioned into different levels.
5. The reachability matrix is developed in the conical form i.e. with most zero (0) variables in upper diagonal half of the matrix and most unitary (1) variables in the lower half.
6. Based on the above a Directed Graph (Digraph) is drawn and transitive links are removed and the resultant Digraph is converted into an ISM by replacing variables nodes with statements.
7. The ISM model is reviewed to check for conceptual inconsistency and to incorporate the necessary modifications.

Enabler Variables for Integration in SCM

Based on literature review and expert opinion, the following SCM Integration parameters have been categorized into three groups, consisting of 14 supply chain integration enabler variables:

1. Strategic level integration enablers
2. Operational level integration enablers
3. Performance level integration enablers

Strategic level integration enablers are the variables that help in the integration of supply chain management at the strategic level; such variables basically influence the strategic level objectives for the supply chain. Some of the enablers are:–

- Top management commitment
- Financial resources
- Collective learning

Operational level integration enabler are the variables that help in the integration of supply chain management at operational level, i.e. such parameters basically influence the operational decisions of supply chain management that may be taken from time to time or periodically (daily, weekly or monthly etc.). Some of these parameters are:–

- Collaborative Planning Forecasting and Replenishment (CPFR)
- Enterprise resource planning (ERP)
- JIT Tools e.g. Kanban
- Point of Sale (POS) Information
- Information sharing
- Logistics synchronization
- Profit sharing
- Customer Relationship Management (CRM)

Performance level integration enablers are variables that indicate the performance of the supply chain management and its integration. Some of these parameters are

- Customer satisfaction

- Buyer supplier relationship
- Lead time reduction

Top Management Commitment

Commitment of top management is crucial to the success of any effort aimed at changing the strategic and operational philosophy of the organization. Without the support of the management the behaviour of the members of the organization is unlikely to change. It has been argued that change will be more successful if upper management is committed to the change (Senge, 1990). The critical role of top managers in shaping the success of strategic changes in organizations is also noted often (Bourgeois and Eisenhardt, 1988). Top management plays a decisive role in paradigm shifts in critical areas such as quality management, product development and other innovation (Hoffman and Hagerty, 1994; Johne and Snelson, 1989). Top management commitment at every stage of the supply chain is one of the essential parameters towards its integration. When top management reveals its commitment, this may provide subordinates with salient clues for impressing upper management. Thus, when a firm attempts to implement a planned change, employees at all levels are more likely to invest time and effort in the change programme if this has the full and credible support of top management (Cole et al., 1993; Krantz, 1989).

Financial Resources

It denotes funds and other resources to support the infrastructure and manpower requirements for the integration of supply chain management. The smooth and efficient flow of material and information need good financial back up to develop effective logistics and information infrastructure. All the entities of the supply chain need some funds, information systems, relevant software etc. for effective focus on supply chain management. Information Technology (IT) is one of the most important enablers of the supply chain management. IT infrastructure requirement is essential because without this, the information accessing, information creating and information sharing is not possible. Financial resources are required for the development of IT infrastructure, logistics, transport and warehousing etc.

Collective learning

This denotes the coordination of collective learning deals with how to tackle the coherency problem of initiation and diffusion of knowledge across organizational borders (Sawhney and Prandelli, 2000). Special emphasis is placed on practical learning from one another for understanding and creating unspoken capability in implementing particular logistics improvement initiatives. Mastering unspoken capability involves intensive dialogue, experimentation and discussion of data, information and knowledge to attain collective sense making (Senge, 1990). The objective of the coordination of collective learning is to extend each partner's capability that is useful for accomplishing ongoing improvements throughout the supply chain.

Collaborative Planning Forecasting and Replenishment (CPFR)

CPFR is a web-based attempt to coordinate the various activities including production and purchase planning, demand forecasting and inventory replenishment between supply chain trading partners. Its objective is to exchange selected internal information on a shared Web server in order to provide for reliable, longer term future views of demand in the supply chain (Fliedner, 2003). CPFR is designed to improve the flow of goods from the suppliers to the end user. It is also designed to quickly identify any discrepancies in the forecasts, inventory, and ordering data so that the problems can be corrected before they negatively impact sales or profits. Entities can share their sales history, sales projections and other important information with their supply chain partners, and they in turn share their raw material availability, lead times and other important information. Then the information is integrated, synchronized, and used to eliminate excess inventory and improve in-stock positions, making everyone in the supply chain more profitable.

Enterprise resource planning (ERP)

ERP is a business management system that integrates all facets of the business, including planning, finance, manufacturing, sales and marketing. ERP systems have become fixtures to provide a basis for business process management integration across business functions (Mabert et al., 2000) As the ERP methodology has become more popular, software applications have emerged to help business managers implement ERP in business activities such as inventory control, order tracking, customer service, finance and human resources. Early enterprise resource planning (ERP) systems were not primarily focused on the supply chain. Their initial focus was to execute and integrate such internally oriented applications that support finance, accounting, manufacturing, order entry, and human resources. Even in the early days, however, a link to the supply chain management (SCM) was present in the form of inventory management.

JIT Tools e.g. Kanban

JIT, Just-in-time, is capable of improving profits and return on investment by reducing inventory levels (increasing the inventory turnover rate), reducing variability, improving product quality, reducing production and delivery lead times, and reducing other costs (such as those associated with machine setup and equipment breakdown). The *kanban* system is an element of just-in-time system that can be used in the integration of the entities in the supply chain management. *kanban* is a Japanese word that means "visible sign" or "card". An advantage of the *kanban* system is its ability to control production. Other advantages include its simplicity in production scheduling, reduced burden on operators, ease of identification of parts by the *kanbans* attached to the containers and substantial reduction in paper work. The *kanban* system is viewed as an information system. It contains information such as the *kanban* type, component name and number, the station location and the destination station. Monden (1993) and Suzaki (1987) discuss the different types of *kanbans* and their functions. These include withdrawal *kanbans*, production *kanbans*, supplier *kanbans*, signal *kanbans*, common *kanbans*, tunnel *kanbans*, express *kanbans* and emergency *kanbans*. *Kanban* has been proved to be an effective tool for the pull system supply chain management. In a pull system supply chain management.

POS Information

A Point of Sale information system may include credit card processors, cash drawers, receipt printers, magnetic stripe readers, pole displays, bar code scanners and signature capture pads, all integrated with a computer-based system. Point of Sale Software is used to manage and control all of these components, and to organize product, customer and sale information. Point of Sale (POS) information is very important data to enable JIT tools in supply chain management. This leads to a decrease in lead times achieved through the ability to better anticipate incoming orders from the retailers. Other benefits include a decrease in inventory at the retailer, a decrease in the variability in the system (Simchi-Levi et al., 2000). POS information requires a very effective and quick communications system, and this information can be equally utilized by all the stages of the supply chain.

Information sharing

This is the coordination of information sharing attempts to make relevant, accurate and timely information available to the decision-makers (Lee, 2000). Chain members often have different private information, which is often not shared with others - thus asymmetric information is inherent in supply chains (Simatupang and Sridharan, 2002). For example, the retailer has better projected customer demand compared to the manufacturer. The manufacturer has better information about products, delivery lead-times and production capacity than the retailer (Lee et al., 1997). Traditional communication between the manufacturer and the retailer is made through periodic ordering in large batches. This ordering behaviour distorts original demand information, because demand variance becomes larger, as order data percolate to the upstream members. The idea is, then, to share demand information with the upstream members. The visibility of demand data and inventory at the point of sales allows the upstream members to update forecasts and ensure continuous replenishment of the products.

Information technology (IT) such as the EDI, Internet, intranet, software application packages and decision support systems can be applied to facilitate information sharing with customers and partners, and optimization of supply chain performance. IT applications for customer orientation include informational facility (i.e. online information about custom and standard products, a comprehensive, frequently asked questions section, contact person, return policy, etc.) and transactional facility (e.g. online order submission, order modification, order notification, order tracking, security of online payment and technical assistance). IT applications for partner orientation enable participating members to gain visibility about customer demand (e.g. customer profiles, products, prices, locations, quantity and demand patterns), resource planning (e.g. forecasting, shipping schedules, inventory, capacity, location, lead-times and products), and contract status such as price, automatic ordering, order-status tracking, invoicing, auction, incentive score-board and electronic payment. This level of information sharing acts as the glue that integrates all chain members. IT, for instance, enables chain members to monitor the order fulfillment process from manufacturing, shipping and order receiving. IT applications for optimization provide analysis of supply chain status and various intelligent recommendations for operational and tactical decisions (Simchi-Levi et al., 2000).

Logistics synchronization

Logistics synchronization means recognizing and concerting improvement initiatives that significantly contribute to value creation in the acquisition, consumption and disposition of products and services in today's rapidly changing markets. This typical coordination refers to the market mediation function of a supply chain that aims to match the variety of products reaching the

marketplace with customer needs and wants (Fisher, 1997). Understanding customer demand and concerting inventory management, facility and transportation between partners help to realize improvements in the forms of rapid response to customer requirements, lowered inventory costs, improved product availability, minimum obsolescence and minimum variance of any unexpected events such as forecasting errors and delays that disrupt chain performance (Lambert et al., 1998).

Logistics synchronization also assists participating members to resolve role conflict, so each member can perform specific tasks and assume certain responsibility to ensure the attainment of chain profitability. The real challenges include focusing on core activities that provide real value to the customer, and subordinating other supporting activities to ensure the value creation process. Analyzing the value creation process across the supply chain can provide a road map for strategic initiatives that clarify specific roles for each participating member. Govindarajan and Gupta (2001), suggest three interrelated areas to ensure logistics synchronization:

(1) customer definition;

(2) customer value identification; and

(3) value creation process design.

If the chain members can redefine the customer base, reinvent the concept of customer value, and redesign the end-to-end value chain architecture, then they are likely to create competitive advantage from the customer's viewpoint.

Several strategies of logistics synchronization have been developed based on the principles of logistics management - such as collaborative logistics processes, operational flexibility, logistics postponement and collaborative transportation. The collaborative logistics processes refer to joint decision-making such as assortment planning, joint forecasting, joint inventory management and replenishment (Simchi-Levi et al., 2000). Operational flexibility aims to provide various demand response strategies by considering supply capacity such as make-to-forecast, locate-to-order, amend-to-order and build-to-order (BTO) (Holweg and Pil, 2001). Logistics postponement refers to delaying product differentiation to the latest possible time until customer orders are received (van Hoek, 2001). Collaborative transportation attempts to employ the third-party logistics providers to accomplish inbound and out-bound logistics. Direct shipping, warehousing, and cross docking are three distinct out-bound strategies to deliver goods to end customers (Simchi-Levi et al., 1998).

Profit sharing

Profit sharing defines how decision-makers are to be rewarded or penalized for the decisions they make. Conflict of interest is likely to occur when the existing profit sharing lead to actions that maximize personal gain but often reduce the total profitability (Clemons and Row, 1993). Traditional profit sharing schemes are often based on local costs and short-term concessions that attempt to fill the gap in inventory between chain members. The perverse incentives, such as local inventory cost, transportation cost and lot-size-based quantity discounts, often do not support the value creation process of improving customer services, because those incentives are tied to the action of reducing the internal costs of one stage of the supply chain. This local optimization often sacrifices the total profit (Simchi-Levi et al., 2000). For example, the manufacturer rewards the retailer based on the number of units or lot-size purchased over a set period. The retailer takes advantage of this quantity discount by loading up inventory. Then it sells the product later at the regular price (forward-buying) or sells it to other retailers for profit (diversion) (Clemons and Row, 1993).

One way to resolve such a conflict of interests is to offer incentive schemes linked to the global performance that reflects both value creations for the customers and profitability (Simatupang and Sridharan, 2002). This coordination mode is called incentive alignment that induces the partner behavior, which is consistent with customer focus and total profit (Lee, 2000). Firms that share complementarities of business process will attempt to resolve incentive misalignment in mutually satisfying ways based on a relational contract especially to manage risks associated with demand uncertainty. A relational contract specifies parameters such as price, quantity, time and quality that guide how a buyer places orders and a seller fulfils orders. Examples come in many forms including relationship pricing (i.e. volume-based quantity discounts, functional allowances and promotional allowances); a subsidy for products returned, consignment and price protection; capacity reservation such as back-up agreements and quantity flexibility contracts; tying bonuses to desirable performance, such as minimizing forecasting errors, sales-through, customer service, speed of delivery and product availability; stabilizing the transfer price, such as an every-day-low-price (EDLP) and every-day-low-cost (EDLC), and gain-sharing schemes (Stern et al., 1996; Simchi-Levi et al., 2000) .

CRM

Customer Relationship Management (CRM) is about finding, getting, and retaining customers. It includes the

Table 1: Structural Self-Interaction Matrix (SSIM)

Variables	14	13	12	11	10	9	8	7	6	5	4	3	2
1	V	V	V	V	V	V	V	X	V	V	V	X	V
2	O	O	O	V	O	V	V	V	O	V	V	O	
3	V	X	V	V	V	V	A	A	O	X	X		
4	V	X	V	X	O	V	A	A	X	X			
5	V	A	O	O	O	V	X	A	A				
6	V	O	O	O	O	V	A	A					
7	O	A	O	X	V	V	V						
8	V	X	V	X	V	V							
9	V	X	V	X	O								
10	O	X	V	A									
11	O	X	V										
12	A	X											
13	X												

No.	Variable name	No.	Variable name	No.	Variable name
1	Top management commitment	6	JIT tools e.g. *kanban*	11	Customer relationship management (CRM)
2	Financial resources	7	POS information	12	Customer satisfaction
3	Collective learning	8	Information sharing	13	Buyer-supplier relationship
4	CPFR	9	Logistics synchronization	14	Lead Time Reduction
5	ERP	10	Profit sharing		

methodologies, software, and Internet capabilities that help a company manage customer relationships in an efficient and organized manner. CRM is at the core of any customer-focused business strategy and includes the people, processes, and technology questions associated with marketing, sales, and service, (Peppers and Rogers, 1999). In today's competitive world, organizations looking to implement successful CRM strategies need to focus on a common view of the customer using integrated information systems and contact centre implementations that allow the customer to communicate via any desired communication channel. Customer relationship management is a comprehensive approach that promises to maximize relationships with all customers, including Internet or "e-customers", distribution channel members, and suppliers. Getting to "know" each customer through data mining techniques and a customer-centric business strategy helps the organization to proactively and consistently offer (and sell) more products and services for improved customer retention and loyalty over longer periods of time. Peppers and Rogers (1999) refer to this as maximizing "lifetime customer share", resulting in customer retention and profitability.

Customer Satisfaction

Customer satisfaction is the result of delivering a product or service that meets customer requirements. It includes the degree to which customers are satisfied with the product and/or service received, and can be applied to internal customers or external customers. Customer satisfaction comprises three elements; namely, pre-transaction satisfaction, transaction satisfaction, and post-transaction satisfaction (Chan et al., 2002). Variables that contribute to satisfaction, such as logistics and marketing customer service, are important because ongoing relationships between channel members are contingent on the level of satisfaction of each firm (Jarrell, 1992). If the customer's expectations are not met, customer dissatisfaction will result. And the lower the satisfaction level, the more likely the customer is to stop purchasing the product or service. High levels of customer satisfaction and high rates of customer retention are strongly related to one another and to corporate profitability, (Oliver; 1993). Customer satisfaction comprises three elements namely, pre-transaction satisfaction, transaction satisfaction, and post-transaction satisfaction.

Buyer supplier relationship

The final level of customer value is an increased connection between the firm and its customers through development of a relationship. This makes it more

Table 2: Reachability Matrix

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	0	1	0	1	1	0	1	1	1	0	1	0	0	0
3	1	0	1	1	1	0	0	0	1	1	1	1	1	1
4	0	0	1	1	1	1	0	0	1	0	1	1	1	1
5	0	0	1	1	1	0	0	1	1	0	0	0	0	1
6	0	0	0	1	1	1	0	0	1	0	0	0	0	1
7	1	0	1	1	1	1	1	1	1	1	1	0	0	0
8	0	0	1	0	1	1	0	1	1	1	1	1	1	1
9	0	0	0	0	0	0	0	0	1	0	1	1	1	1
10	0	0	0	0	0	0	0	0	0	1	0	1	1	0
11	0	0	0	1	0	0	1	1	1	1	1	1	1	0
12	0	0	0	0	0	0	0	0	0	0	0	1	1	0
13	0	0	1	1	1	0	1	1	1	1	1	1	1	1
14	0	0	0	0	0	0	0	0	0	0	0	1	1	1

difficult for customers to switch to another provider since a relationship requires an investment of time from both the customer and the provider, (Simchi-Levi et al., 2000). In the mid-twentieth century, mass production techniques and mass marketing changed the competitive landscape by increasing product availability for consumers. However, the purchasing process that allowed the shopkeeper and customer to spend quality time getting to know each other was also fundamentally changed. Customers lost their uniqueness, and shopkeepers lost track of their customer's individual needs as the market became full of product and service options. Many companies today are racing to re-establish their connections to new as well as existing customers to boost long-term customer loyalty. Organizations today must focus on delivering the highest value to customers through better communication, faster delivery, and personalized products and services (Bultema, 2000).

Lead-Time Reduction

Lead-time reduction within the supply chain is the mechanism for time-based competition (Tersine and Hummingbird, 1995). Eliminating delays at various stages invariably improves throughput and customer services. Measures for reductions in design times, cycle times, setup times, throughput times and delivery times are to be taken for over all lead-time reduction. Eliminating delays and improving product flows involves creativity, specialized skills, capital investments and behavioural changes that challenge the status quo. Frequently, significant improvements can be attained with relatively little additional capital investment.

Structural Self-Interaction Matrix (SSIM)

After the identification of variables, which helps in the integration of the supply chain, their contextual relationships are developed. Two variables can be independent each other, they may help each other or one variable helps in the attainment of the other, while the reverse is not true. The existence of a relation between any two sub-variables (i and j) and the associated direction of the relation is questioned. Four symbols are used for the type of the relation that exists between the two sub-variables under consideration:

V for the relation from i to j but not in both directions: In this type of relationship variable i helps in achieving the variable j,

A for the relation from j to i but not in both directions

X for both direction relations from i to j and j to i, and: In this type of relationship i variable help in achieving j and j helps in achieving i.

O if the relation between the variables does not appear valid

For analyzing the variables, a contextual relationship is chosen, such that one variable leads to another. Based on this contextual relationship a SSIM has been developed. To obtain a consensus, the

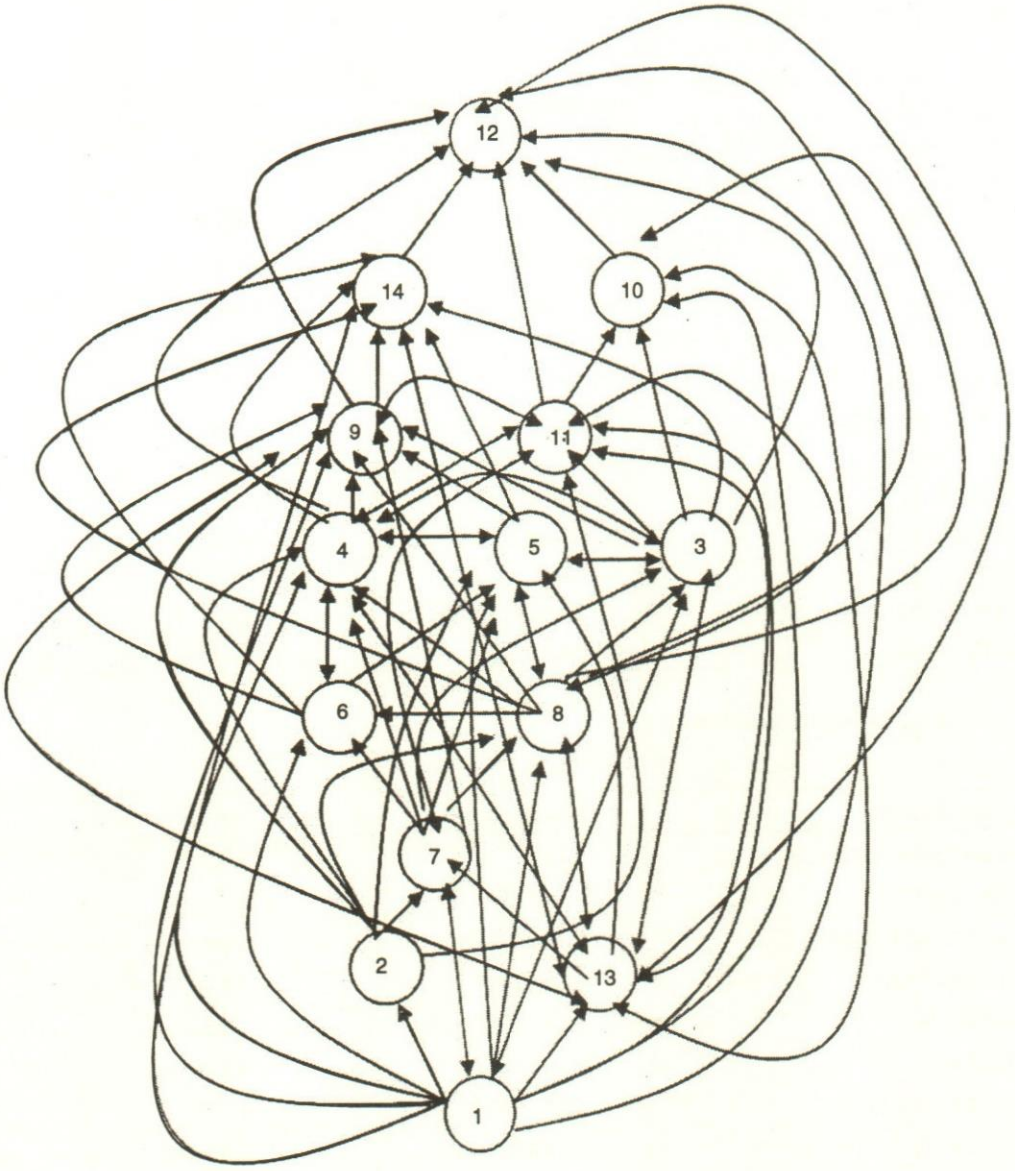

Fig. 2. Diagraph depicting the relationships among the SCM enabler variables

SSIM was discussed by a group of experts. Based on their responses, the SSIM has been presented as shown in Table 1.

Top management commitment (1) is essential to implement and achieve financial resources (2), collective learning (3) CPFR (4), ERP (5), JIT Tools e.g. *kanban* (6), creation of POS information (7); information sharing (8) logistics synchronization (9) profit sharing (10), CRM (11), customer satisfaction (12), buyer supplier relationship (13) and lead time reduction (14) whereas collective learning (3) and POS information (7) leads to top management commitment.

Financial resource needed to meet the expenses in implementation of CPFR (4), ERP (5), POS Information (7), Information sharing (8) and CRM (9). No variable is directly leading to financial resources as for as supply chain integration is concerned. Collective learning leads to CPFR (4), ERP (5), logistics synchronization (9), profit sharing (10), CRM (11), customer satisfaction (12), buyer-supplier relationship (13), and lead-time reduction (14), whereas CPFR (4), ERP (5), POS information (7), information sharing (8) and buyer-supplier relationship (13) leads to collective learning.

CPFR leads to ERP (4) JIT Tools e.g. *kanban* (6), logistics synchronization (9), CRM (11), customer satisfaction (12), buyer-supplier relationship (13) and lead-time reduction (14), whereas ERP (5), JIT Tools e.g. *kanban* (6), POS information (7), Information sharing (8), CRM

Table 3: First Level of SCM Integration variables

Iteration 1

Variable (P)	Reachability Set: R (P)	Antecedent Set: A (P)	Intersection R (P) and A (P)	Level
1	1,2,3,4,5,6,7,8,9,10,11,12,13,14	1,3,7	1,3,7	
2	2,4,5,7,8,9,11	1,2,10,13	2	
3	1,3,4,5,9,10,11,12,13,14	1,3,4,5,7,8,13	1,3,4,5,13	
4	3,4,5,6,9,11,12,13,14	1,2,3,4,5,6,7,11,13	3,4,5,6,11,13	
5	3,4,5,8,9,14	1,2,3,4,5,6,7,8,13	3,4,5,8	
6	4,5,6,9,14	1,4,6,7,8	4,6	
7	1,3,4,5,6,7,8,9,10,11	1,2,7,11,13	1,7,11	
8	3,5,6,8,9,10,11,12,13,14	1,2,4,6,7,8,11,13	6,8,11.13	
9	9,11,12,13,14	1,2,3,4,5,6,7,8,9,11,13	9,11,13	
10	10,12,13	1,3,7,8,10,11,13	10,13	
11	4,7,8,9,10,11,12,13	1,2,3,4,7,8,9,11,13	7,7,8,9,11,13	
12	12,13	1,3,4,8,9,10,11,12,13,14	12,13	I
13	3,4,5,7,8,9,10,11,12,13,14	1,3,4,8,9,10,11,12,13.14	3,4,8,9,10,11,12,13,14	
14	12,13,14	1,3,4,5,6,8,9,13,14	13,14	

Table 4: Second Level of SCM Integration variables

Iteration 2

Variable	Reachability Set	Antecedent Set	Intersection set	Level
1	1,2,3,4,5,6,7,8,9,10,11,13,14	1,3,7	1,3,7	
2	2,4,5,7,8,9,11	1,2,10,13	2	
3	1,3,4,5,9,10,11,12,13,14	1,3,4,5,7,8,13	1,3,4,5,13	
4	3,4,5,6,9,11,13,14	1,2,3,4,5,6,7,11,13	3,4,5,6,11,13	
5	3,4,5,8,9,14	1,2,3,4,5,6,7,8,13	3,4,5,8	
6	4,5,6,9,14	1,4,6,7,8	4,6	
7	1,3,4,5,6,7,8,9,10,11	1,2,7,11,13	1,7,11	
8	3,5,6,8,9,10,11,13,14	1,2,4,6,7,8,11,13	6,8,11.13	
9	9,11,13,14	1,2,3,4,5,6,7,8,9,11,13	9,11,13	
10	10,13	1,3,7,8,10,11,13	10,13	II
11	4,7,8,9,10,11,13	1,2,3,4,7,8,9,11,13	7,7,8,9,11,13	
13	3,4,5,7,8,9,10,11,13,14	1,3,4,8,9,10,11,13.14	3,4,8,9,9,10,11,13,14	
14	13,14	1,3,4,5,6,8,9,13,14	13,14	II

and buyer-supplier relationship (13) leads to CPFR. ERP leads to Information sharing (8), logistics synchronization (9) and lead-time reduction (14), whereas JIT Tools e.g. *kanban* (6), POS information (7), information sharing (8) and buyer-supplier relationship leads to ERP.

JIT Tools e.g. *kanban* (6) leads to logistics synchronization (9) and lead-time reduction (14) whereas information sharing (8) and POS information (7) leads to JIT Tools e.g. *kanban*.

POS information leads to logistics synchronization (9), profit sharing (10), information sharing (8) and CRM (11), whereas CRM (11) and buyer-supplier relationship (13) leads to POS information.

Information sharing leads to logistics synchronization (9), profit sharing (10), CRM (11), customer satisfaction (12), buyer-supplier relationship (13) and lead-time reduction (14) whereas CRM (11) and buyer-supplier relationship (13) leads to information

Table 5: Third Level of SCM Integration variables

Iteration 3

Variable	Reachability Set	Antecedent Set	Intersection set	Level
1	1,2,3,4,5,6,7,8,9,11,13	1,3,7	1,3,7	
2	2,4,5,7,8,9,11	1,2,13	2	
3	1,3,4,5,9,11,13	1,3,4,5,7,8,13	1,3,4,5,13	
4	3,4,5,6,9,11,13	1,2,3,4,5,6,7,11,13	3,4,5,6,11,13	
5	3,4,5,8,9	1,2,3,4,5,6,7,8,13	3,4,5,8	
6	4,5,6,9	1,4,6,7,8	4,6	
7	1,3,4,5,6,7,8,9,11	1,2,7,11,13	1,7,11	
8	3,5,6,8,9,11,13	1,2,4,6,7,8,11,13	6,8,11.13	
9	9,11,13	1,2,3,4,5,6,7,8,9,11,13	9,11,13	III
11	4,7,8,9,11,13	1,2,3,4,7,8,9,11,13	7,8,9,11,13	III
13	3,4,5,7,8,9,11,13	1,3,4,8,9,11,13	3,4,8,9,11,13	

Table 6: Fourth Level of SCM Integration variables

Iteration 4

Variable	Reachability Set	Antecedent Set	Intersection set	Level
1	1,2,3,4,5,6,7,8,13	1,3,7	1,3,7	
2	2,4,5,7,8	1,2,13	2	
3	1,3,4,5,13	1,3,4,5,7,8,13	1,3,4,5,13	IV
4	3,4,5,6,13	1,2,3,4,5,6,7,13	3,4,5,6,13	IV
5	3,4,5,8	1,2,3,4,5,6,7,8,13	3,4,5,8	IV
6	4,5,6	1,4,6,7,8	4,6	
7	1,3,4,5,6,7,8	1,2,7,13	1,7	
8	3,5,6,8,13	1,2,4,6,7,8,13	6,8,13	
13	3,4,5,7,8,13	1,3,4,8,13	3,4,8,13	

sharing (8). Logistics synchronization leads to CRM (11), customer satisfaction (12), buyer-supplier relationship (13) and lead-time reduction (14) whereas CRM (11) and buyer-supplier relationship (13) leads to logistics synchronization.

Profit sharing leads to customer satisfaction (12) and buyer-supplier relationship (13) whereas CRM (11) and buyer-supplier relationship (13) leads to profit sharing (10).

Customer satisfaction (12) leads to buyer-supplier relationship (13) whereas buyer-supplier relationship (13) and lead-time reduction (14) leads to customer satisfaction. Lead-time reduction leads to buyer-supplier relationship and vice versa.

Reachability Matrix

The SSIM format is transformed into a reachability matrix format by transforming the information in each entry of the SSIM into 1's and 0's in the reachability matrix. The methodology of performing is as follows:

1. If the (i, j) entry in the SSIM is V, then the (i, j) entry in the reachability matrix becomes 1 and (j, i) entry becomes 0.
2. If the (i, j) entry in the SSIM is A, then the (i, j) entry in the reachability matrix becomes 0 and (j, i) entry becomes 1.
3. If the (i, j) entry in the SSIM is X, then the (i, j) entry in the reachability matrix becomes 1 and (j, i) entry becomes 1.
4. If the (i, j) entry in the SSIM is O, then the (i, j) entry in the reachability matrix becomes 0 and (j, i) entry becomes 0.

Following these rules, reachability matrix for the variation is prepared as shown in table 2

Table 7: Fifth Level of SCM Integration variables

Iteration 5

Variable	Reachability Set	Antecedent Set	Intersection set	Level
1	1,2,6,7,8,13	1,7	1,7	
2	2,7,8	1,2,13	2	
6	6	1,6,7,8	6	V
7	1,6,7,8	1,2,7,13	1,7	
8	6,8,13	1,2,6,7,8,13	6,8,13	V
13	7,8,13	1,8,13	8,13	

Table 8: Sixth Level of SCM Integration variables

Iteration 6

Variable	Reachability Set	Antecedent Set	Intersection set	Level
1	1,2,7,13	1,7	1,7	
2	2,7	1,2,13	2	
7	1,7	1,2,7,13	1,7	VI
13	7,13	1,13	13	

Table 9: Seventh & Eighth Levels of SCM Integration variables

Iteration 7

Variable	Reachability Set	Antecedent Set	Intersection set	Level
1	1,2,13	1	1	VIII
2	2	1,2,13	2	VII
13	13	1,13	13	VII

Partitioning the reachability Matrix

The matrix is partitioned by assessing the reachability and antecedent sets for each variable. The variable for which the reachability and the intersection sets are the same is given the top level variable in the ISM hierarchy, which would not help achieve any other variable above their own level. After the identification of the top-level element, it is discarded from the other remaining variables. From Table 3 it is seen that customer satisfaction (12) is found at level 1. Thus it would be positioned at the top of the ISM model. This iteration is continued till the levels of each variable are found out. The identified levels aids in building the final model of ISM. The process is completed in seven iterations as follows:

The levels of ISM model are found as Customer satisfaction (12) is put in level 1. Profit sharing (10) and Lead-time reduction (14) are placed at level II. Logistics synchronization (9) and CRM (11) are placed at level III. Collective learning (3), CPFR (4) and ERP (5) are placed at level IV. JIT Tools e.g. *kanban* (6) and Information sharing (8) are placed at level V. POS information (7) is placed at level VI. Financial resources (2) and buyer-supplier relationship are placed at level VII. Top management commitment (1) is placed at level VIII.

Developing Conical Matrix

A conical matrix is developed by clubbing together variables in the same level, across rows and columns of the final reachability matrix, as shown in Table 10.

Development of the Diagraph

Based on the conical form of reachability matrix, the initial diagraph including transitive links is obtained as shown in Fig. 2. After removing indirect links, the final digraph is obtained as shown in Fig. 3.

From Fig. 4, it is observed that Top management commitment (1) plays significant role in SCM integration and it comes at the base of ISM hierarchy. Customer satisfaction (12) is SCM integration variable on which effectiveness of SCM integration depends. Customer

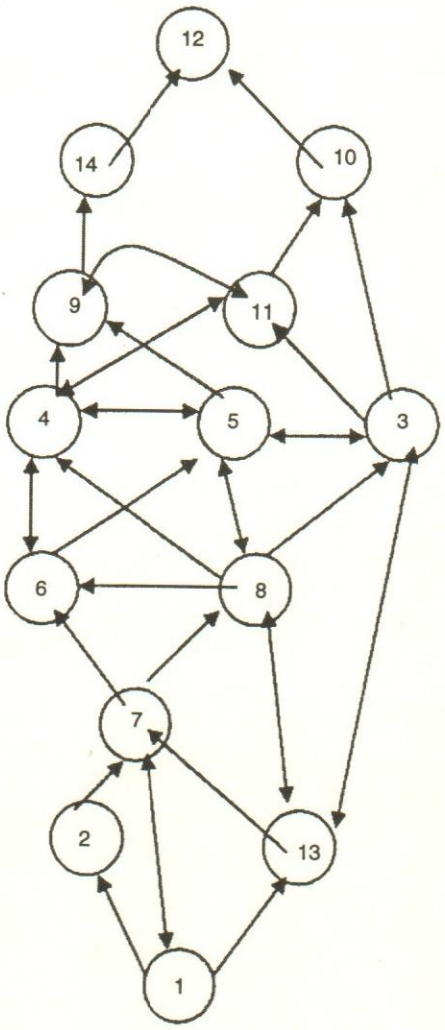

Fig. 3. Diagraph showing the levels of SCM integration enablers

satisfaction appeared at the top of the hierarchy.

For integration of supply chain, it is top management commitment that arranges required financial resources and maintains the buyer-supplier relationship. These are the basic drivers of the SCM integration and appear at the bottom level of the hierarchy after the top management commitment. Financial resources lead to information sharing by providing an effective communication and information infrastructure, and at the same time buyer-supplier relationships leads to Information sharing and POS information.

Without buyer-supplier relationships, information sharing and true POS information is not possible. POS information is a very important input for JIT tools e.g. *kanban* and information sharing; this is the reason for placing at the bottom level after financial resources and buyer-supplier relationship. Information sharing leads to collective learning, CPFR and ERP. Collaborative planning and ERP needs the outcome data of information sharing. JIT tools e.g. *kanban* leads to CPFR and ERP both. CPFR and ERP lead to logistics synchronization. Information, sharing, particularly POS information leads to CRM. Collective learning is the enabler that basically leads towards profit sharing and CRM. Customer satisfaction in the environment of supply chain integration depends on the delivery in time and cost effectiveness. Delivery in time and the cost effectiveness both depends on the two enablers, namely lead time reduction and profit sharing. So lead time reduction and profit sharing both leads to customer satisfaction, hence they are enablers directly connected with the customer satisfaction.

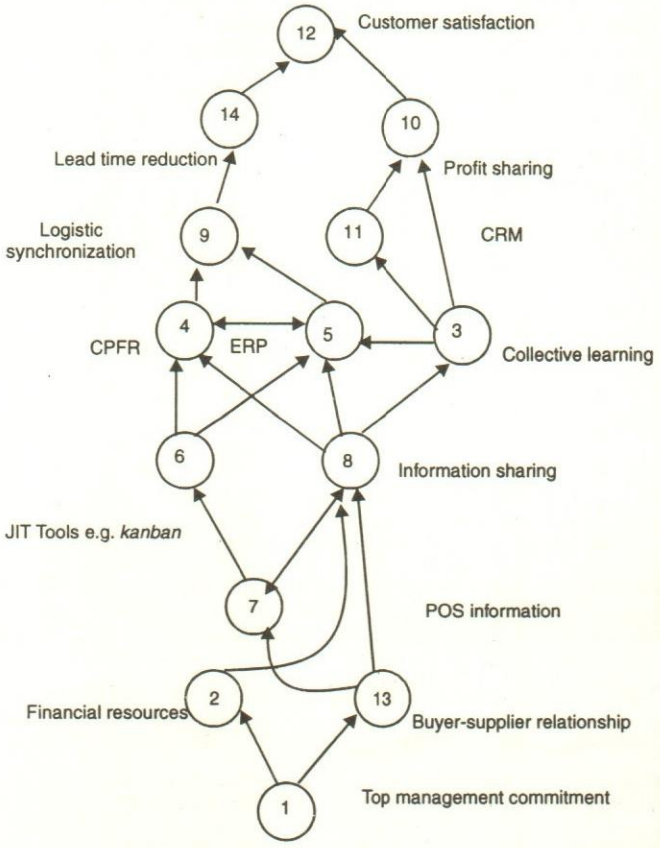

Fig. 4. Interpretive Structural model showing the levels of SCM integration variables

MICMAC Analysis

The objective of MICMAC analysis is to analyze the driving power and dependence of SCM integration enabler variables (Mandal and Deshmukh, 1994). The SCM integration variables are classified into four clusters. The first cluster includes "autonomous variables" that have weak driving power and weak dependence. These variables are relatively disconnected from the system, with which they have only few links, which may be strong. The second cluster consists of

Table 10: Conical Form of Reachability Matrix

Variables	12	10	14	9	11	3	4	5	6	8	7	13	2	1
12	1	0	0	0	0	0	0	0	0	0	0	1	0	0
10	1	1	0	0	0	0	0	0	0	0	0	0	0	0
14	1	0	1	0	0	0	0	0	0	0	0	1	0	0
9	1	1	1	1	1	0	0	0	0	0	0	1	0	0
11	1	1	0	1	1	0	1	0	0	1	1	1	0	0
3	1	1	1	1	1	1	1	1	0	0	0	1	0	1
4	1	0	1	1	1	1	1	1	1	0	0	1	0	0
5	0	0	1	1	0	1	1	1	0	1	0	0	0	0
6	0	0	1	1	0	0	1	1	1	0	0	0	0	0
8	1	1	1	1	1	1	0	1	1	1	0	1	0	0
7	0	1	0	1	1	1	1	1	1	1	1	0	0	1
13	1	1	1	1	1	1	1	1	0	1	1	1	1	0
2	0	0	0	1	1	0	1	1	0	1	1	0	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 11: Driving power and Dependence in Reachability Matrix

Variables	12	10	14	9	11	3	4	5	6	8	7	13	2	1	Driving power	Rank
12	1	0	0	0	0	0	0	0	0	0	0	1	0	0	2	X
10	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	X
14	1	0	1	0	0	0	0	0	0	0	0	1	0	0	3	IX
9	1	1	1	1	1	0	0	0	0	0	0	1	0	0	6	VII
11	1	1	0	1	1	0	1	0	0	1	1	1	0	0	8	V
3	1	1	1	1	1	1	1	1	0	0	0	1	0	1	9	IV
4	1	0	1	1	1	1	1	1	1	0	0	1	0	0	9	IV
5	0	0	1	1	0	1	1	1	0	1	0	0	0	0	6	VII
6	0	0	1	1	0	0	1	1	1	0	0	0	0	0	5	VIII
8	1	1	1	1	1	1	0	1	1	1	0	1	0	0	1	0
7	0	1	0	1	1	1	1	1	1	1	1	0	0	1	1	0
13	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	2
2	0	0	0	1	1	0	1	1	0	1	1	0	1	0	7	VI
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	I
Dependence	10	9	10	11	9	7	4	4	5	7	5	8	3	3		
Ranks	II	III	II	I	III	V	VII	VII	VI	V	VI	IV	VIII	VIII		

dependent variables that have weak driver power and strong dependence. These variables are unstable. Any action on these variables will have an effect on others and also a feed back effect on themselves. The fourth cluster includes independent variables having strong driving power but weak dependence. It is observed that a variable a very strong driving power, known as the key variables, falls into the category of independent variables. In Table 10, an entry of "1" along the columns and rows indicates the dependence and driving power respectively.

The variables are categorized into ranks. For example variable 4 is seventh rank in dependence and fourth in driving power while variable 2 is sixth in driving power and eighth in dependence. Four categories are presented in Fig. 6. Top management commitment (1), financial resources (2), collective learning (3), POS infor-

mation (7), information sharing (8) and CPFR (4) come under category IV and are therefore categorized as independent drivers. It can be seen in figure 6 that Top management commitment (1) is the strongest driver, as far as driving power is concerned information sharing (8), POS information (7), CPFR (4), collective learning. (3) and financial resources (2) come in descending order respectively. As far as dependence is concerned Top management commitment (1) and financial resources (2) are the least dependent enablers.

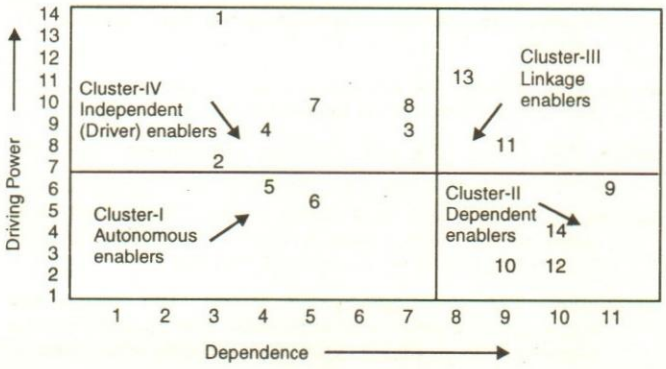

Fig. 5. Clusters of the entities in the integration of supply chain management

JIT Tools e.g. *kanban* (6) and ERP (5) are autonomous variables and are kept under category 1. Profit sharing (10), logistics synchronization (9), lead-time reduction (14), Customer satisfaction (12), are found as dependent variables. Buyer-supplier relationship has high driving power in supply chain integration and so many times it plays a key role in the integration process, and at the same time it has high dependence also. Buyer-supplier relationship (13) and CRM (11) are linkage variables with high dependence but high driving power.

Conclusion

The development of ISM for SCM integration variable results in the following findings:

Ranks of the elements based on their driving power indicate that top management commitment (1) is the key variable in SCM integration. It has strong driving power and less dependence on other variables under study. Information sharing has also strong driving power next to management commitment (1) but comparatively more dependence. Collective learning (3) and POS information (7) have similar driving power but POS information is less dependent. Financial resources (2) has less driving power than other independent variables but it has least dependence.

ERP (5) and JIT tools e.g. *kanban* (6) are less dependent on other variables, JIT tools has less driving power than ERP. These variables play a less significant role in integration of the supply chain.

Dependent variables are logistics synchronization (9), profit sharing (10) lead-time reduction (14) and customer satisfaction (12). Out of these customer satisfaction (12), profit sharing (10) and lead-time reduction have strongest dependence with least driving power. Logistics synchronization (9) but it shows high dependence.

CRM (11) and buyer-supplier relationship (13) are fall under the category of linkage variables. These variables are unstable. Any action on these variables has a great impact on supply chain integration. These also have a feedback effect on themselves. This shows that the success or failure of CRM (11) and particularly the buyer-supplier relationship (13) marks the success or failure of SCM integration.

The levels of enablers are important in understanding the prioritization of enablers in the SCM integration process. Top management commitment, financial resources; buyer-supplier relationship, POS information, collective learning and information sharing are the key bottom-line enablers in SCM integration process. Financial resources are essential to create an effective communication and information infrastructure to boost the enablers like information sharing, ERP, CPFR, CRM. It is shown in Fig. 5 that top management commitment possesses the highest driving power, and is the key enabler in arranging financial resources. This is the reason for placing top management commitment in the top-most level of the hierarchy. Management commitment, financial resources and information and communication infrastructure should be checked first to measure the ability of the business to integrate SCM.

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□

You're not a real manager unless you've been sacked.

– Malcolm Allison

Feature

Performance of Power Generation in Andhra Pradesh

Mukesh Kumar & Trupti Mishra

This paper makes an attempt to study the trends in technical efficiency of different power generation plants in Andhra Pradesh during the period spanning 1982-83 to 2000-01, by the technique of non-parametric (DEA) as well as the parametric frontier with specification of Cobb-Douglas production function approach. Among all the inputs, underutilization of "power" and "capacity" are found to be the major causes of inefficiency of electricity generation in Andhra Pradesh.

Mukesh Kumar is faculty (Economics), School of Business and Management, KUTPM, Malaysia; and Trupti Mishra is faculty (Economics), ICFAI Business School, Bangalore.

The evolution of the energy sector in India has mirrored the economic growth strategy of the country. In post-independence India, the political necessity of keeping the country together and the need for large-scale investments in infrastructure and manufacturing industry laid the foundation for the government's involvement in this sector. Success with government supported agriculture growth policies in the sixties and political pressure to win votes through populist measures resulted in controls being tightened and increased government investment in economic activities. Consequently, public expenditure continued to grow and the share of public sector in GDP and organized employment increased from 13 per cent and 58 per cent in 1970-71 to 27.1 per cent and 71 per cent in 1988-89, respectively. Public sector investments were financed by government deficits funded through domestic borrowings and printing of currency. Fiscal deficit remained over 8 per cent of GDP in the mid-eighties. During the late eighties, the Indian economic system cracked under the burden of external (large trade and current account deficit) and internal imbalances (inflation and large government borrowings). However, this time the government responded by opening up the Indian economy to domestic as well as international competition. The government realized that the country had missed an opportunity to attract international investment for export-led growth, a strategy adopted by many of the countries in East Asia.

The generation, transmission and distribution of electricity in India have traditionally been a government enterprise. In today's scenario, where the power sector in India is plagued by several problems, reforms are inevitable; restructuring of the industry to improve the efficiencies has already seen light in the form of unbundling. In this context, a very good example is the state of Andhra Pradesh, which has unbundled its generation and transmission activities.

A number of studies have been carried out to estimate the production and cost functions, using both

DEA and stochastic frontier approaches in the electricity industry particularly with reference to US applications. Some of the studies are discussed here.

Seitz (1971) applied the frontier methods to electricity generation for the analysis of 181 steam-electric plants. The linear programming technique was used to calculate the technical, allocative and overall efficiency measures. Further, it investigates the sources of technical efficiency with respect to a number of firm-specific factors. Schmidt and Lovel (1979) used the data on 111 US steam-electric plants to illustrate extensions of the stochastic frontier model to allow for allocative inefficiency. Studies made by Stevenson (1980) and Greene (1980) also use US data to investigate more general inefficiency error distributions and more flexible forms, respectively.

Kopp and Smith (1980) estimate stochastic frontier production functions for 43 US coal-fired electric power plants. They consider three alternative functional forms; three estimation methods; and also divide their data into two capital vintage groups, finding that all three factors have influence upon the measures of mean technical efficiency obtained.

A number of papers applied the DEA models as well to US electricity data during the 1980s. The Fare, Grosskopf and Logan (1983) studies considered the efficiency of Illinios electric utilities and relative efficiency of public and privately owned utilities, respectively. The studies by Fare, Grosskopf and Pasurka (1986) investigated the effects of environmental regulation upon relative efficiency.

This paper makes an attempt to study the efficiency trend of electricity power generation in Andhra Pradesh during the period spanning 1982-83 to 2000-01. The non-parametric technique of DEA is used to evaluate the technical efficiency of each plant independently for each observation (year) relative to the efficiency of all other observation (years) and itself. Also the parametric technique with specification of Cobb-Douglas production function is used to estimate the mean efficiency as well as predict the efficiency of all plants by using the pooled data.

Method of Analysis

Currently, two methods are used to measure Technical Efficiency (TE): Econometric estimation of production frontiers and Data Envelopment Analysis (DEA). The econometric approach to estimating TE assumes an explicit functional form for the underlying production technology. In contrast, DEA, originally pioneered by Charnes *et al,* (1978), does not require any underlying assumptions. It enables one to obtain extremal relations such as the production function and/or production possibility surfaces. Instead of trying to fit a regression plane, it floats piecewise-linear/Cobb-Douglas (log-linear) surface to rest on the top of the observations (Seiford, 1990)

Measurement of Technical Efficiency: DEA

The extent by which a firm lies below its production frontier, which sets the limit to the range of maximum obtainable output, can be regarded as the measure of technical efficiency. The concept of technology and output-oriented technical efficiency can be well explained with the held of Figure 1, involving single input (x) and single output (y). Consider an industry consisting of four firms - A, B, C and D.

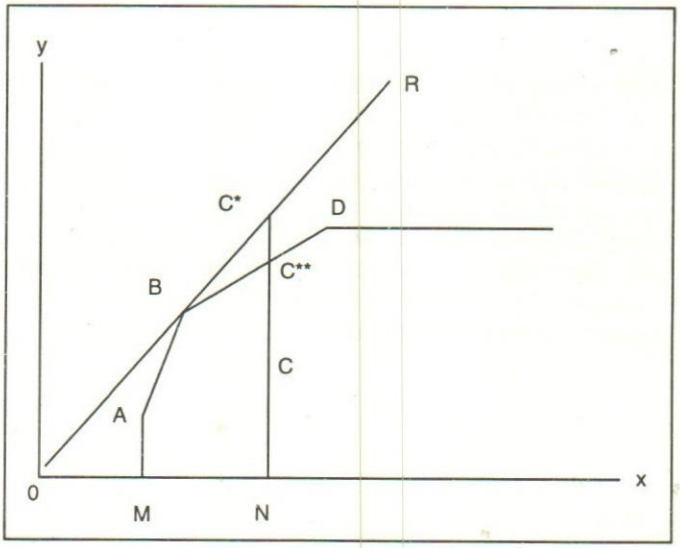

Fig. 1

Given the free disposability of inputs and output and convexity condition, the free disposal convex hull of the observed input-output vectors provides us an inner approximation to the true underlying production possibility set. If additionally, one assumes constant returns to scale (CRS), all non-negative input-output bundles will also be feasible. The production possibility set becomes a convex cone. By convexity, all points in the convex hull of the points A, B, C and D (i.e., all convex combinations of these points) represent feasible input-output combinations.

The free disposal convex hull is a set of points bounded by the horizontal axis and the broken line MABD – extension. Under VRS, all points in this region represent feasible input-output combinations. Under CRS, however, all radical extension and (non-negative)

contractions of feasible input-output bundles are also feasible. Thus the CRS production possibility set is the cone formed by the horizontal axis ad the ray OR through the point B. As can be seen from the Figure 1, firm C is technically inefficient as it is lying below the frontier of the technology. The output-oriented technically efficiency is measured by the amount by which output could be increased without requiring extra inputs. In other words, it is the ratio of actual output to potential output. Hence, the technical efficiency of the firm C is the ratio NC/NC* under CRS and the ratio NC/NC** under VRS.

Let k = 1, ..., K firms using n = 1, ..., N inputs to produce m = 1, ..., M outputs at each time period t = 1, ..., T.

The reference frontier (or technology) in period t is constructed from the data as:

$$S^t = (x^t, y^t) : y_m^t \le \sum_{k=1}^{K} Z^{k,t}\ y_m^{k,t} ; \sum_{k=1}^{K} z^{k,t} x_n^{k,t} \le x_n^t ; z^{k,t} \ge 0 \qquad ...(1)$$

which exhibits constant returns to scale and strong disposability of inputs and outputs (Fare *et al*, 1994). Following Sidney Afriat (1972), the assumption of CRS can be relaxed and one may allow for variable returns to scale by putting the following restriction in (1) (Banker *et al*, 1984):

$$\sum_{k=1}^{K} Z^{k,t} = 1 \qquad ...(2)$$

where, $Z^{k,t}$ is an intensity variable indicating at what intensity a particular activity (farm) may be employed in production.

The distance function seeks the reciprocal of the greatest proportional increase in output(s) given input(s), such that output is still feasible.

The output distance function at t is defined as:

$$D_0^t = \text{Min}\,\theta : \left(x^t, \frac{1}{\theta} y^t\right) \in S^t \qquad ...(3)$$

It completely characterizes the technology $D_0 t \le 1$, if and only if $(x^t, y^t) \in S^t$. In addition, $D_0^t = 1$, if and only if (x^t, y^t) is on the boundary or frontier of the technology.

The output distance function under CRS technology is calculated by following the linear programming problem:

$$\left\{D_0^t (x^t, y^t)\right\}^{-1} = \max \theta^{k'}$$

$$\text{s.t} \sum_{k=1}^{K} Z^{k,t}\ x_n^{k,t} \le x_n^{k',t} \qquad n = 1, 2, ..., N$$

$$\sum_{k=1}^{K} Z^{k,t}\ y_m^{k,t} \ge y_m^{k',t}\theta \qquad m = 1, 2, ..., M$$

$$Z^{k,t} \ge 0, \qquad k = 1, 2, ..., K \qquad ...(4)$$

The output distance function under VRS technology can be calculated by putting the restriction (2) in the above LP problem.

Measurement of Technical Efficiency: SFA

Battese and Coelli (1992) propose a stochastic frontier production function for (unbalanced) panel data, which has firm effects, and are assumed to be distributed as truncated normal random variables, which are also permitted to vary systematically with time. The model may be expressed as:

$$Y_{it} = x_{it}\beta + (V_{it} - U_{it}) \ ,i = 1, ..., N, t = 1, ..., T, \qquad ...(5)$$

where, Y_{it} is (the logarithm of) the production of the i-th firm in the t-th time period;

x_{it} is a k × 1 vector of (transformations of the) input quantities of the i-th firm in the t-th time period;

β is as defined earlier;

the V_{it} are random variables which are assumed to be iid $N(0, \sigma v^2)$, and independent of the

$U_{it} = U_i \exp(-\eta (t - T))$, where

the U_i are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be iid as

technical at zero of the $N(\mu, \sigma_U^2)$ distribution;

η is a parameter to be estimated;

and the panel of data need not be complete (i.e. unbalanced panel data.

We utilise the parameterization of Batteses and Corra (1977) who replace σ_V^2 and σ_U^2 with $\sigma_2 = \sigma_V^2 + \sigma_U^2$ and $\gamma = \sigma_U^2/(\sigma_V^2 + \sigma_U^2)$. This is done with the calcula-

tion of the maximum likelihood estimates in mind. The parameter, g, must lie between 0 and 1 and thus this range can be searched to provide a good starting value for use in an iterative maximization process such as Davidon-Fletcher-Powell (DFP) algorithm.

The imposition of one or more restrictions upon this model formulation can provide a number of the special cases of this particular model, which have appeared in the literature. Setting η to be zero provides the time-invariant model set out in Battese, Coelli and Colby (1989). Furthermore, restricting the formulation to a full (balanced) panel of data gives the production function assumed in Battese and Coelli (1988). The additional restriction of m equal to zero reduces the model to model One in Pitt and Lee (1981). One may add a fourth restriction of T = 1 to return to the original cross-sectional, half-normal formulation of Aigner, Lovell and Schmidt (1977). Obviously a large number of permutations exist. For example, if all these restrictions excepting $\mu = 0$ are imposed, the model suggested by Stevenson (1980) results. Furthermore, if the cost function option is selected, we can estimate the model specification in Hughes (1988) and the Schmidt and Lovell (1979) specification, which assumed allocative efficiency. These latter two specifications are the cost function analogues of the production functions in Battese and Coelli (1988) and Aigner, Lovell and Schmidt (1977), respectively.

Database

The sample data used in this study comprises of the data from 4 thermal generating stations in the State of Andhra Pradesh. They are:

1. Ramagundam Thermal Station (RTS)
2. Vijayawada Thermal Power Station (VTPS)
3. Kothagudem Thermal Power Station (KTPS)
4. Nellore Thermal Station (NTS)

The 4 plants considered here take coal as the most important component of fuel and oil is used almost in all the plants for unit restarts. The average capacity of each plant is about 592.5 mw which average unit size being 148-mw indicating about 4 units per each plant. The largest plant capacity is about 1260-mw comprising of 6 units each of 210 mw. And the smallest plant capacity is NTS with a capacity of 3-mw comprising of a single unit. Coming to the ages of the plants, they vary significantly from the newly commissioned plants to the one commissioned about 40 years back. The average age of the plants is somewhere between 23-24 years.

Coming to the data, a number of choices had to be made when deciding upon the measures to be taken. To begin with, when considering an output measure a choice had to be made between the electricity produced versus electricity sent out. Engineers generally prefer the first measure, but from an economic point of view, the amount of power sent out is the measure of useful output in he sense that it is being consumed with no regards to he losses. But here the power produced is not directly consumed by the end consumers since the power is procured by he transmission authorities from this stage and then passed on to the subsequent stage, which is why the total output produced is directly taken as an output measure. The capital measure used here is the nameplate capacity (in mw). This was not a preferred choice, because a measure of he overall capital investment adjusted for depreciation and embodied technical change would have been a better measure. But the relevant data was not available. Again the input for labour is the number of employees. A degree of training and the number of working hours would have been preferable. But the data was not made available.

The most difficult decision was however the selection of the inputs, especially the fuel input. The most obvious choice here is the amount of coal burnt. This is so because we are considering only the case of coal-fired power plants. This measure, however, suffers from a number of problems. First and foremost the quality of coal varies significantly from one region to another. The fuel issue is further complicated by the amounts of various other fuels used like the oil for the unit restarts after a period of down time. It was thus decided that the best way to avoid these problems was to convert all the fuels into their equivalent joule terms and then aggregate the resulting figures.

The relevant data was obtained from the employees at *vidyutsoudha* and the remaining data was available from the MIS manual of *APGENCO*.

Results and Discussion

Table 1: Summary Statistics

Variables	Minimum	Maximum	Average
Capacity	30	1760	592
Output	5502	21933	11275.5
Labour	4578	10134	6257.3
Fuel	3036.8	16428.2	7539.6
Average life of units	8	40	24-25
Average unit size	30	210	148
Coal	3.93	16.35	9.03

Table 1 gives the summary statistics of different plants taken fro this study. As it can be observed the

capacity of the plant varies between 30 to 1760 mw, the average being 592 observed the capacity of the plant varies between 5502 to 21933 MU, the average being 11275 MU. Similarly, one can observe the variations with respect to other variables across the plants.

The efficiency scores through stochastic frontier estimates with Cobb Douglas production function specifications are shown in Table 2 for all the plants during the period spanning 1982-83 to 2000-01. As can be observed from the Table 2, the efficiency trend is a downward sloping one. On an average plant 2 (VTPS) is performing the best as compared to other plants. On the other hand, the plant 4 (NTS) is performing much below the average efficiency, the efficiency varying from 0.697 in 1982-83 to 0.519 in 2000-01. The mean efficiency in electricity generation in Andhra Pradesh varies from 0.872 in 1982-83 to 0.789 in 2000-01.

Table 2: Efficiency Scores: Stochastic Frontier Production Function Estimate

Efficiency	Plant I RTS	Plant 2 VTPS	Plant 3 KTPS	Plant 4 NTS	Mean Efficiency
1982-83	0.882	0.984	0.926	0.697	0.872
1983-84	0.878	0.983	0.924	0.689	0.868
1984-85	0.874	0.983	0.921	0.680	0.865
1985-86	0.870	0.983	0.919	0.671	0.861
1986-87	0.866	0.982	0.916	0.663	0.857
1987-88	0.862	0.982	0.913	0.653	0.853
1988-89	0.857	0.981	0.911	0.644	0.848
1989-90	0.853	0.980	0.908	0.635	0.844
1990-91	0.849	0.980	0.905	0.625	0.840
1991-92	0.844	0.979	0.902	0.615	0.835
1992-93	0.839	0.978	0.899	0.605	0.830
1993-94	0.834	0.978	0.895	0.595	0.826
1994-95	0.829	0.977	0.892	0.585	0.821
1995-96	0.824	0.976	0.889	0.574	0.816
1996-97	0.818	0.975	0.885	0.563	0.811
1997-98	0.813	0.975	0.882	0.552	0.805
1998-99	0.807	0.974	0.878	0.542	0.800
1999-00	0.802	0.973	0.874	0.530	0.795
2000-01	0.796	0.972	0.870	0.519	0.789

As against the results shown in Table 2 (based on stochastic frontier analysis), there is little deviation in the results obtained through DEA. Efficiency score estimated by using BBC model have been reported in Tables 3 to 6 for different plants. The first column shows the year followed by the efficiency score in column 2. The rest of the columns show the potential improvement of different inputs—capacity, fuel, power, oil and labour during the study period.

Table 3: Efficiency scores and potential improvements: RTS

RTS Year	Efficiency Score	Potential Improvements				
		Capacity	Fuel	Power	Oil	Labour
1982-83	100	0	0	0	0	0
1983-84	96.32	8.23	3.68	3.68	12.03	3.68
1984-85	95.34	30.68	4.66	4.66	11.07	26.97
1985-86	100	0	0	0	0	0
1986-87	100	0	0	0	0	0
1987-88	82.56	18.1	17.44	17.44	17.44	21.78
1988-89	100	0	0	0	0	0
1989-90	94.33	45.34	5.67	5.67	13.93	48.34
1990-91	94.54	5.46	5.46	5.46	7.97	12.78
1991-92	84.58	21.58	15.42	15.42	15.42	26.46
1992-93	83.45	47.88	16.55	37.3	19.61	56.82
1993-94	85.97	14.03	14.03	14.03	14.03	28.53
1994-95	89.91	17.86	10.09	10.09	10.09	33.3
1995-96	90.03	18.32	9.97	30.78	9.97	34.22
1996-97	90.39	16.39	9.61	58.92	9.61	34.24
1997-98	87.8	12.2	12.2	49.58	14.93	32.04
1998-99	85.7	20.18	14.3	64.96	14.3	38.35
1999-00	98.92	10.88	1.08	1.08	12.05	31.26
2000-01	90.06	9.94	16.09	39.31	18.05	32.09

Table 4: Efficiency scores and potential improvements: VTPS

Year	Efficiency Score	Potential Improvements				
		Capacity	Fuel	Power	Oil	Labour
1982-83	93.01	11.05	6.99	69.04	35.12	6.99
1983-84	94.35	5.65	5.65	61.13	30.62	5.65
1984-85	95.43	12.94	4.57	18.87	39.83	11.28
1985-86	100	0	0	0	0	0
1986-87	98.81	1.19	1.19	0.06	18.45	1.19
1987-88	100	0	0	0	0	0
1988-89	92.27	7.73	7.73	32.01	12.07	10.61
1989-90	83.35	31.94	16.15	72.83	40.07	16.15
1990-91	87.82	30.21	12.18	62.32	22.26	12.18
1991-92	91.09	21.38	8.91	64.41	21.47	8.91
1992-93	92.86	16.4	7.14	47.24	17.94	7.14
1993-94	90.42	12.95	9.58	55.07	14.13	9.58
1994-95	94.17	14.41	5.83	82.53	11.78	5.83
1995-96	99.1	4.01	1.01	50.68	0.9	0.9
1996-97	100	0	0	0	0	0
1997-98	100	0	0	0	0	0
1998-99	98.28	4.92	1.72	10.4	2.78	1.72
1999-00	98.1	5.66	3.58	1.9	1.9	1.9
2000-01	100	0	0	0	0	0

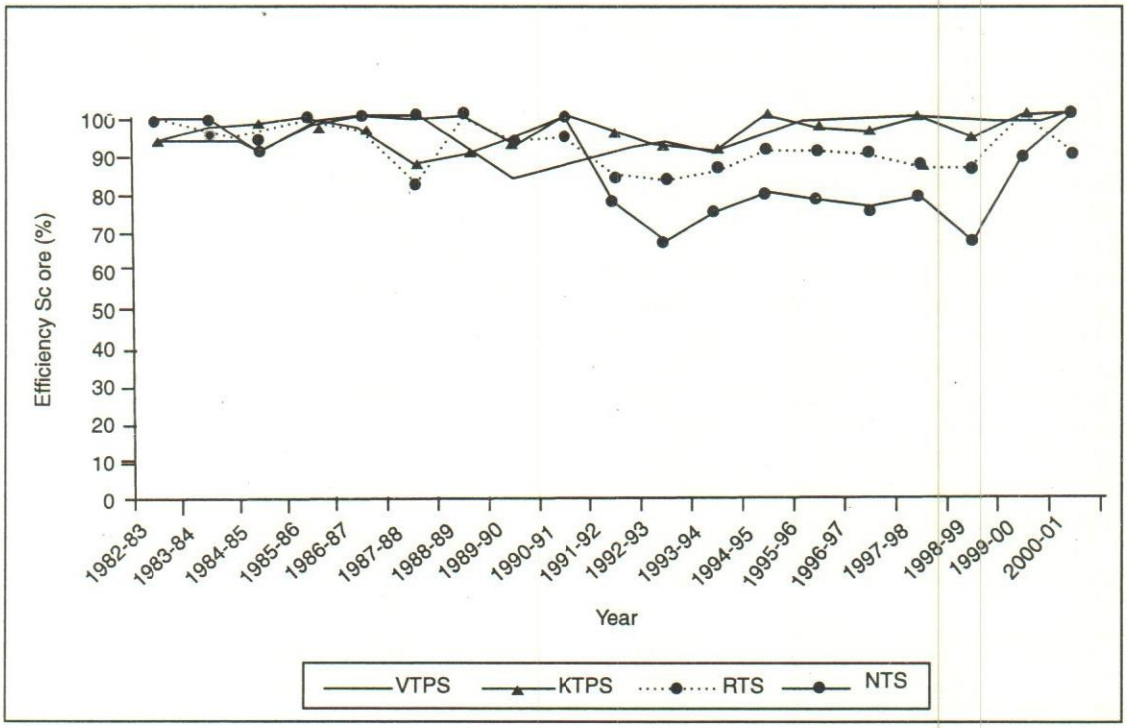

Fig. 2. Trends in Relative Efficiency of Different Plants

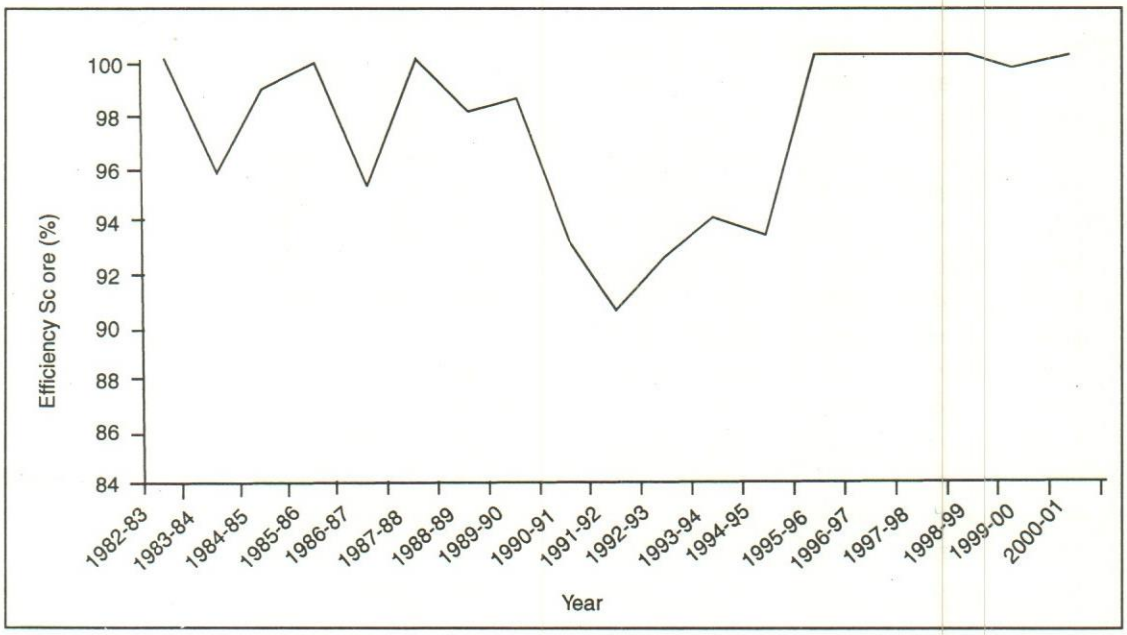

Fig. 3. Trends in Relative Efficiency: All Plants

As one can observe from Tables 3 to 6, the efficiency scores vary across the years in all the plants. However, the trends in technical efficiency don't vary much among the plants. The efficiency score is found to be reasonably good in the early years as well as the last few years of the study as compared to the efficiency in the middle years as shown in Figures 2 and 3.

As observed from Table 3, the plant 1 (RTS) was found to be efficient in 1982-83, 1985-86, 1986-87 and 1988-89. In rest of the years the plant was found to be inefficient, the lowest being in the year 1987-88 with the efficiency score 82.56. The potential improvements shown in the rest of the column indicate by what percentage the different inputs can be reduced to achieve

the targeted output. For example, the inputs – capacity, fuel, power, oil and labour could have been reduced respectively by 20 per cent, 14 per cent, 65 per cent 15 per cent and 32 per cent and still the current level of output could have been achieved during the year 1998-99. The efficiency scores of plants 2 to 4 along with potential improvements of all the inputs are reported in Tables 4 to 6.

Table 5: Efficiency scores and potential improvements: KTPS

Year	Efficiency Score	Potential Improvements				
		Capa-city	Fuel	Power	Oil	Labour
1982-83	94.04	27.68	5.96	80.78	14.1	23.48
1983-84	98.35	22.39	1.65	64.14	9.15	19.41
1984-85	98.37	10.89	1.63	1.63	5.53	6.3
1985-86	100	0	0	0	0	0
1986-87	96.78	7.56	3.22	3.22	5.49	3.22
1987-88	87.59	25.27	12.41	30.55	12.41	31.03
1988-89	90.23	31.21	9.77	20.9	9.77	37.01
1989-90	94.47	36.91	12.48	52.27	5.53	44.45
1990-91	100	0	0	0	0	0
1991-92	96.3	3.7	3.7	3.7	6.34	5.15
1992-93	91.71	9.16	8.29	8.29	8.29	15.04
1993-94	90.76	19.65	9.24	9.24	9.24	25.61
1994-95	100	0	0	0	0	0
1995-96	96.3	8.13	3.7	3.7	3.7	15.34
1996-97	95.69	17.56	4.31	4.31	4.31	29.52
1997-98	100	0	0	0	0	0
1998-99	94.46	18.01	5.54	53.99	5.54	14.16
1999-00	100	0	0	0	0	0
2000-01	100	0	0	0	0	0

The overall efficiency scores during the period of study are shown in Table 7. As one can observe, the trend in efficiency is a fluctuating one till 1992-93. It starts showing an upward trend afterwards and achieves the full efficiency in the year 1995-96 through 2000-01. The major sources of loss in efficiency in this industry are found to be "misuse of power" and "under-utilization of capacity". On an average, the use of these two inputs could have been reduced respectively by 35 per cent and 34 per cent and still the current levels of output could have been achieved.

Conclusion

An attempt has been made in this study to estimate

Table 6: Efficiency scores and potential improvements: NTS

Year	Efficiency Score	Potential Improvements				
		Capa-city	Fuel	Power	Oil	Labour
1982-83	100	0	0	0	0	0
1983-84	100	0	0	0	0	0
1984-85	91.92	12.45	8.08	8.08	8.08	8.08
1985-86	98.5	4.56	1.5	1.5	5.9	1.5
1986-87	100	0	0	0	0	0
1987-88	100	0	0	0	0	0
1988-89	100	0	0	0	0	0
1989-90	92.82	7.18	7.18	7.18	7.18	12.11
1990-91	100	0	0	0	0	0
1991-92	77.76	22.45	22.24	33.27	22.24	29.82
1992-93	66.68	35.5	33.01	56.31	33.13	41.64
1993-94	74.4	25.6	25.6	38.44	25.6	37.79
1994-95	79.25	27.71	20.75	20.75	20.92	39.24
1995-96	78.47	21.53	21.53	38.36	21.53	32.71
1996-97	75.77	28.79	24.43	55.13	24.43	41.39
1997-98	77.59	24.61	22.31	45.24	22.31	39.71
1998-99	67.54	38.91	32.46	38.82	32.46	50.88
1999-00	89.36	10.74	10.74	10.74	11.83	17.47
2000-01	100	0	0	0	0	0

Table 7: Efficiency scores and potential improvements: All Plants

Year	Efficiency Score	Potential Improvements				
		Capa-city	Fuel	Power	Oil	Labour
1982-83	100	0	0	0	0	0
1983-84	95.75	21.39	4.25	4.25	4.25	14.61
1984-85	98.97	13.81	1.03	1.03	6.28	14.53
1985-86	100	0	0	0	0	0
1986-87	95.15	20.24	4.85	4.85	4.85	6.79
1987-88	100	0	0	0	0	0
1988-89	97.88	36.68	2.12	14.92	2.12	25.01
1989-90	98.5	48.25	1.5	71.66	1.5	33.4
1990-91	93.23	42.09	6.77	32.35	6.77	21.88
1991-92	90.44	38.53	9.56	41.81	9.56	19.31
1992-93	92.36	36.3	7.64	42.5	7.64	19.79
1993-94	93.76	35.82	6.24	56.62	6.24	21.78
1994-95	93.21	35.43	6.79	69.79	6.79	13.68
1995-96	100	0	0	0	0	0
1996-97	100	0	0	0	0	0
1997-98	100	0	0	0	0	0
1998-99	100	0	0	0	0	0
1999-00	99.45	0.55	0.55	0.55	1.19	0.55
2000-01	100	0	0	0	0	0

the efficiency trend of electricity power generation in Andhra Pradesh during the period 1982-83 to 2000-01. The non-parametric technique of DEA has been used to calculate plant-wise efficiency scores under the assumption of variable returns to scale. In addition, the stochastic frontier model with specification of Cobb-Douglas function is used to estimate the mean efficiency as well as to predict the efficiency of individual plant by using the pooled data. SFA estimates show that the overall efficiency trend is found to be downward sloping in all the plants. However, the use of DEA Indicates that the efficiency trend is a downward sloping one in almost all plants during the middle periods. Efficiency is found to be comparatively better during the initial and end years. Among all the inputs, "power" and "capacity" are the dominating source of loss in efficiency during the period of study.

Power is the key input for industrial as well as economic development. As power can neither be stored nor imported, investment in new capacity is the only way to augment supply, which is a prerequisite for sustainable growth. Today there is enormous pressure on the sector in terms of energy deficit and shooting peak demand. India continues to be a power-starved nation even after fifty years of planning and a vast experience of putting up 90,000 mw generating capacity with associated transmission and distribution systems. India is one among the many countries with low per capital consumption of power.

Amidst all these facts, certain inefficiencies both sectoral and institutional like insufficient capacity addition, high T and D losses and lack of proper information systems are bugging the sector. These have over the years resulted in poor financial viability of the sector. Governments are gearing up efforts in the direction of reforming the sector. The consumption per head can be achieved partially by improving the efficiency of the electricity generating plant by efficiently utilizing the resources, particularly by reducing the misuse of power and full utilization of capacity of the plant.

One of the major limitations of this study is the limited number of observation, as we have taken only 4 plants into consideration. So, a comparative study across the different plants through DEA is missing, as the analysis has been done separately for each plant by taking the observations over the years. In order to overcome this problem of comparability of efficiency across the plants, we have used the pooled data (both cross as well as time-series) in SFA. So, the results obtained from these models can not be compared with that of DEA.

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Feature

Promotion of Foreign Direct Investment (FDI) in India and China

Arabi U

This paper concludes that the benefits of FDI flows in the recipient countries depends on the extent of capital account liberalization, the size of the domestic market and other supportive policies of the host county. It is observed that the recent economic reforms measures experimented in China and India enhanced the growth of both economies, which is perhaps due to the efforts of these countries to evolve effective strategic growth-oriented FDI policies in recent years.

Arabi U is Reader, Department of Economics, Mangalore University, Karnataka.

Most developing countries consider Foreign Direct Investment (FDI) as an important channel for accessing resources for economic development. FDI represents transfer of a bundle of assets like capital, technology, and access to export markets, skills and management techniques and modern environment management system.

Over the last two decades there has been a change in the approach towards assessing the impact of FDI flows on the recipient economy. In the earlier approaches, the impact of FDI on growth was found to be limited in the short-run since long-term growth was largely considered to be contingent upon technological progress (Grossman and Helpman, 1991). On the other hand, according to the more recent endogenous growth theory, FDI is considered as a composite of capital, know-how and technology (Balasubramanyam et al, 1996). Under this approach, FDI can have a permanent positive impact on economic growth by generating increasing returns to scale through externalities and positive productivity spillovers (de Mello, 1997).

Empirical investigations have found that the positive impact of FDI is generally higher for recipient countries with a higher level of development (Blomstorm et al, 1994). Such findings support the arguments that in the absence of a minimum threshold level of development, the positive impact of FDI would remain confined to particular FDI enclaves of the economy (Borensztein et al, 1995). Moreover, the benefits of FDI can be realized fully only if the economy's saving rate is less than domestic investment, i.e., in the context of a current account deficit. On the other hand, if the absorptive capacity of the economy is weak, higher FDI inflows could end up in higher foreign exchange reserves. The spillover effect of FDI is also found to be the highest in industries with high level of technical development and low concentration of foreign firms. Indigenous technology capabilities have been found to be positively associated with technology import, research and development in the recepient country, output growth

and manufacturing exports (Zhao, 1995). Some studies have found that compared with firms under pure domestic ownership, FDI firms generally have higher capital intensity, export-to-sales ratio and imported input component (O' Sullivan, 1993). There is, however, a tendency of technology imports to shift from physical capital – Intensive to human capital-intensive type over time. The economic benefits of FDI are generally difficult to measure with precision. However, it may be noted that, a liberal policy towards FDI inflow is necessary, but not sufficient for reaping the benefits of globalization. Market failures may occur for attracting FDI flows.

The economic benefits of FDI are generally difficult to measure with precision.

Though there is no ideal strategy for the use of FDI as applicable to all countries at all times, a good strategy must be context-specific, reflecting a county's level of economic development, the resource base, the specific technological context, the competitive setting, and the Government's capabilities to implement policies. For instance, countries like Malaysia, Singapore and Thailand pursued policies to rely substantially on FDI, while integrating the economy into Transnational Corporations (TNCs), production networks and promoting competitiveness by upgrading within those networks. On the other hand, countries like China, Korea etc. have pursued policies to develop domestic enterprises and autonomous innovative capabilities, relying on TNCs mainly as sources of technology.

Trends in Global FDI Flows

Most FDI has been directed towards the developed world, although the share of developing countries had been growing steadily until 1997, when it reached a peak of around 40 per cent (Table 1). The important characteristics feature of FDI flows to Emerging Market Economies (EMEs) in the 1990s were, firstly, there was a rapid increase in FDI inflows in the 1990s, owing largely to the adoption of macroeconomic and structural reforms by a number of these countries and the strengthening of their growth prospects. Secondly, the surge in FDI, especially in the latter of the 1990s, was led by increased merger and acquisition activity. Thirdly, for a number of countries there was a significant shift to FDI into the service sector in tandem with the increasing share of service activities in these host countries. In fact, traditionally, FDI was directed towards the development of natural resources and manufacturing enterprises.

Most of the recent studies conclude that FDI is a relatively stable type of capital flow (Radelet and Sachs. 1998). During the period 1992-97, commercial bank loans displayed the highest volatility, as measured by the coefficient of variation, followed by portfolio investment and FDI. Another study in respect of 12 major developing economies and countries in transition for the same period, based on annual data, confirmed that the volatility of foreign portfolio investment was generally higher than that of FDI (UNCTAD, 1998). Further, FDI flows continue to be concentrated in China, Hong Kong (China) and Singapore. The top 10 host economies took 93 per cent of the regions total inflows in 2002. Further, FDI flows to North-East Asia 16 dropped from $78 billion in 2001 to $70 billion in 2002. FDI flows to Hong Kong (China) fell by 42 per cent, partly because TNC production activities were relocated to lower cost locations, primarily China. The decline in FDI flows was also partly due to slow economic growth of these economies. The notable exception was China.

FDI flows to South-East Asia dropped from $15 billion in 2001 to $14 billion in 2002, through Brunei Darussalam. Lao People's Democratic Republic, Malayia and the Philippines received larger flows than in 2001. Significant repayments of intra-company loans by foreign affiliates were a feature of the decline, as was the increased competition from China. FDI flows to South Asia increased from $4.0 billion in 2001 to $4.6 billion in 2002, due to higher flows to India, Pakistan and Sri Lanka. FDI flows to Bangladesh and other countries in the sub-region declined. However, in the case of Bangladesh, FDI flows in 2002 would have been higher if investment in kind were included. FDI flows to West Asia declined in 2002 to $2.3 billion, from $5.2 billion in 2001. Despite the recent efforts of some countries in this sub-region to relax FDI restrictions, flows continue to be low, with geopolitical tensions being a major factor. Some countries have large oil reserves. After reaching a peak in 2000, global FDI inflows declined in the subsequent years. In 2002, a handful of countries like China, Brazil, Hong Kong, Mexico, Singapore, India and Malaysia accounted for around 70 per cent of total FDI flowing into developing countries (Table 1). The source of FDI in East Asia has predominantly been the region within itself – Hong Kong and Taiwan together account for about 45 per cent of FDI in the major recipient countries in the region including China. These two sources are inseparable, since a significant amount of investment from Taiwan is channeled through Hong Kong and they together account for almost 70 per cent of FDI in China. After the East Asian Newly Industrialized Economies (NIEs), Japan ranks as the second largest investor in the region – its investments are spread

Table 1: FDI Inflows by Host Region and Economy (U.S. $ Billion) (Figures in brackets indicate percentage to the total)

Host Region/ Economy	1991-1996 (Average)	1997	1998	1999	2000	2001	2002
World (% to total)	254.3 (100)	481.9 (100)	686.0 (100)	1097.1 (100)	1393.0 (100)	823.8 (100)	651.2 (100)
Developed Economies	154.6 (60.8)	269.7 (56.0)	472.3 (68.8)	824.6 (76.4)	1120.5 (80.4)	589.4 (71.5)	460.3 (7.7)
Central and Eastern Europe	8.2 (3.2)	19.0 (3.9)	22.5 (3.3)	25.1 (2.3)	26.4 (1.9)	25.0 (3.0)	28.7 (4.4)
Developing Economies	91.5 (36.0)	193.2 (40.1)	191.3 (27.9)	229.3 (21.2)	246.1 (17.7)	209.4 (25.4)	162.1 (24.9)
Of which:							
Latin America and the Caribbean	27.1 (29.6)	73.3 (37.9)	82.0 (42.9)	108.3 (47.2)	95.4 (38.8)	83.7 (40.0)	56.0 (34.5)
Argentina	4.3 (4.7)	9.2 (4.7)	7.3 (3.8)	24.0 (10.5)	11.7 (4.7)	3.2 (1.5)	1.0 (0.6)
Brazil	3.6 (4.0)	19.0 (9.8)	28.9 (15.1)	28.6 (12.5)	32.8 (13.3)	22.5 (10.7)	16.6 (10.2)
Chile	2.2 (2.4)	5.3 (2.7)	4.6 (2.4)	8.8 (3.8)	3.6 (1.5)	4.5 (2.1)	1.6 (1.0)
Colombia	1.3 (1.4)	5.6 (2.9)	2.8 (1.5)	1.5 (0.6)	2.2 (0.9)	2.5 (1.2)	2.0 (1.3)
Asia	59.4 (64.9)	109.1 (56.5)	100.0 (52.3)	108.5 (47.3)	142.1 (57.7)	106.8 (51.0)	95.0 (58.6)
China	25.5 (27.8)	44.2 (22.9)	43.8 (22.9)	40.3 (17.6)	40.8 (16.6)	46.8 (22.4)	52.7 (32.5)
Hong Kong SAR	6.1 (6.6)	11.4 (5.9)	14.8 (7.7)	24.6 (10.7)	61.9 (25.2)	23.8 (11.4)	13.7 (8.5)
India	1.2 (1.3)	3.6 (1.9)	2.5 (1.3)	2.2 (0.9)	4.0 (1.6)	6.1 (2.9)	4.7 (2.9)
Indonesia	3.0 (3.3)	4.7 (2.4)	-0.4 (0.2)	–2.7 (–1.2)	–4.6 (–1.8)	–3.3 (–1.6)	–1.5 (–0.9)
Korea, Republic of	1.2 (1.3)	2.8 (1.5)	5.4 (2.8)	9.3 (4.1)	9.3 (3.8)	3.5 (1.7)	2.0 (1.2)
Malaysia	5.4 (5.9)	6.3 (3.3)	2.7 (1.4)	3.9 (1.7)	3.8 (1.5)	0.6 (0.3)	3.2 (2.0)
Philippines	1.2 (1.3)	1.3 (0.7)	1.7 (0.9)	1.7 (0.8)	1.3 (0.5)	1.0 (0.5)	1.1 (0.7)
Singapore	6.9 (7.5)	13.5 (7.0)	7.6 (4.0)	13.2 (5.8)	12.5 (5.1)	10.9 (5.2)	7.7 (4.7)
Taiwan Province of China	1.3 (1.4)	2.2 (1.2)	0.2 (0.1)	2.9 (1.3)	4.9 (2.0)	4.1 (2.0)	1.4 (0.9)
Thailand	2.0 (2.1)	3.9 (2.0)	7.5 (3.9)	6.1 (2.7)	3.4 (1.4)	3.8 (1.8)	1.1 (0.7)

Source: World Investment Report, UNCTAD, 2003; Reserve Bank of India, 2004.

more or less equally between China, Malaysia and Thailand.

Foreign Direct Investment in China and India

India and China received large FDI flows in the 1990s. FDI flows to China are, however, ten times of that in respect to India (Table 2). The timing, pacing and content of FDI liberalization and the overall development strategy in the two countries seem to account for the difference in FDI performance. In UNCTAD's FDI Performance Index, India ranked 122nd in FDI performance. China was placed much higher at the 54th position. A

recent business environment survey indicated that China is more attractive than India in terms of the macroeconomic environment, market opportunities and policy orientation towards FDI. India, on the other hand, scored better on the political environment, taxes and financing (EIU, 2003). A Federation of Indian Chambers of Commerce and Industry (FICCI) survey suggests that China has a better FDI policy framework, market growth, consumer purchasing power, rate of return, labour law and tax regime than India (FICCI, 2003).

Table 2: China and India: Selected FDI indicators

Item	Country	1990	2000	2001	2002
1. FDI Flows (US.$ billion)	China	3.5	40.0	46.8	52.7
	India	0.1	4.0	6.1	4.7
2. Inward FDI Stock (US$ billion)	China	24.8	348.3	395.2	447.9
	India	1.5	21.0	27.1	31.8
3. Growth of FDI Inflows (Annual %)	China	2.8	1.1	14.9	12.5
	India	-76.3	97.0@	52.2	-24.0
4. FDI Stock to GDP (%)	China	7.0	32.3	33.2	35.2
	India	0.5	4.5	5.6	6.2
5. FDI Flows to Gross Fixed Capital Formation (%)	China	3.5	10.3	10.5	N.A.
	India	0.1	3.9	5.8	
6. FDI Flows per Capita (US $)	China	3.0	32.0	36.5	40.7
	India	0.1	3.9	5.9	4.5

@ The large increase is due to change in definition.

Source: World Investment Report (UNCTAD) 2003, Reserve Bank of India (2004)

China and India – Reasons for difference in FDI performance

China's exceptional growth is partly explained by its market-based reforms that started in 1978, well before India'a similar reforms began in 1991. These reforms have enabled China to integrate with the global economy at a phenomenal pace. Today it is the largest recipient of foreign direct investment among developing countries, with the annual investment rising from almost zero in 1978 to about $52 billion in 2002 (nearly 5 per cent of GDP). Foreign direct investment in India has also increased significantly, though at much lower levels, growing from $129 million in 1991 to $4 billion in 2002 (less than 1% of GDP). On the way to the new economy, China is gradually becoming the world manufacturing centre for IT equipment and products, while India has gained the leading position in software technology and has become the second largest software country in the world.

Since the mid-1990s, trading activities between the two countries greatly increased, economic cooperation, such as labour, technical cooperation and inter-investment had been widely developed. Both enjoy healthy rates of economic growth. But there are significant differences in their FDI performance. FDI flows to China grew from $3.5 billion in 1990 to $52.7 billion in 2002; if round-tripping is taken into account, China's FDI inflows could fall to, say $40 billion. Those to India rose from $0.4 billion to $5.5 billion during the same time period. Even with these adjustments, China attracted seven times more FDI than India in 2002, 3.2 per cent of its GDP compared with 1.1 per cent for India. In UNCTAD's FDI Performance Index, China ranked 54th and India 122nd in 1999-2001. FDI has also contributed to the rapid growth of China's merchandise exports, at an annual rate of 155 between 1989 and 2001. In 1989 foreign affiliates accounted for less than 9 per cent of total Chinese exports; by 2002 they provided half. In some high-tech industries in 2002 the share of foreign affiliates in total exports was as high as 91 per cent in electronic circuits and 96 per cent in mobile phones (WIPR-2002). About two-thirds of FDI flows to China in 2000-2001 went to manufacturing.

In India, by contrast, FDI has been much less important in driving India's export growth, except in information technology. FDI in Indian manufacturing has been and remains domestic market seeking. FDI accounted for only 3 per cent of India's exports in the early 1990s (WIPR, 2002). Even today, FDI is estimated to account for less than 10 per cent of India's manufacturing exports. For China the lion's share of FDI inflows in 2000-2001 went to a broad range of manufacturing industries. For India most went to services, electronics and electrical equipment and engineering and computer industries.

The differential performance of India and China in attracting the FDI inflows has been the subject of attention at the international level (UNCTAD, 2003). Further, the difference in FDI inflows to India and China can be attributed partly to definitional and conceptual issues. For instance, a part of the difference in FDI inflow to India and China can be traced to data reporting. A sizable portion of the FDI in China is investment made by the Chinese from foreign locations – the so-called "round tripping" – and this takes place to a large extent due to special treatment extended by the Chinese authorities towards foreign investors' *via-a-vis* domestic investors. The round tripping is much smaller in India and takes place mainly through Mauritius for tax purposes. Estimates suggest that 30 per cent of the reported FDI in China may in fact be a result of round-tripping (UNCTAD, 2003).

Another major factor could be the earlier initiation of reform measures in China (1978) as compared to India

(1991). Moreover, China's manufacturing sector productivity is 1.6 times that of India and, in some sectors, as much as five times (McKinsey, 2001). Flexible labour laws, a better labour climate and entry and exit procedures for business, business-oriented and more FDI–friendly policies also make China an attractive destination. Investors underscore the predictability and stability of the tax system as an important factor in determining investment decision. Higher import duties on raw materials in India result in higher prices of inputs, as most domestic players resort to import parity pricing. China has a flat 17 per cent VAT rate, while India's indirect taxes range from 25 per cent to 30 per cent of the retail price from most manufactured products. The emergence of China as a member of the World Trade Organisation (WTO) in 2001 is a stabilizing anchor and has led to substantial liberalization in the services sector (RBI 2004). It is also important to note that India and China focused on different strategies for industrial development. India encouraged FDI only in higher technology activities, whereas China favoured export-oriented FDI concentrated in manufacturing sector. China's strategy is based on the premise that an increasing proportion of international trade is inter-firm trade between multinationals, and in such an environment there is no alternative to attracting FDI for export. China's FDI–driven merchandise exports grew at an annual rate of 15 per cent between 1969 and 2001. In 1989, foreign affiliates accounted for less than nine per cent of total Chinese exports; by 2002 these accounted for half of the exports and in high-tech industries the proportion was much higher (World Investment Report, 2003).

In contrast, in India, given its product reservation policy for Small Scale Industries (SSIs), FDI is not permitted in SSI-reserved products such as garments and toys, which has adverse implications for export growth. In India, exports by FDI companies grew at an average of around 9 per cent during 1990-91 to 2001-02. A major factor in the growth of Chinese exports was the relocation of labour intensive activities by TNCs to China. However, in India this has happened mainly in the services sector. Almost all major U.S. and European information technology firms have a presence in India now. Foreign companies dominate India's call centre industry, with a 60 per cent share of the annual US$ 1.5 billion turnover (World Investment Report, 2003).

Despite large FDI flows, restrictions on the organisational forms of FDI entry are still prevalent in China. For instance, in 31 industries the establishment of wholly foreign-owned enterprises is not allowed and the Chinese partners must hold majority share holdings or a dominant position in another 32 sectors (OECD, 2002). A view has been expressed that China's large absorption of FDI is not necessarily a sign of the strength of its economy; instead, it may be a sign of some, rather substantial, distortions (Huang, 2003). It is argued that FDI plays a major role in the Chinese economy due to systematic and pervasive discrimination against efficient and entrepreneurial domestic firms. Furthermore, unlike India, a vibrant private sector is absent in China and most of the foreign investors must perform tie-up with only state-owned behemoths for joint ventures.

Basic determinant

National policies are the key for attracting FDI, and these policies have to be seen in the boarder context of the determinants of FDI, among which economic factors predominate (Table 3). Policies are decisive in preventing FDI from entering a country. The best way of attracting and drawing benefits from FDI is not always passive liberalization (an "open door" policy). Liberalization can help to get more FDI, but alone it is not enough. Attracting FDI in a highly competitive market for investment now requires stronger locational advantages and more focused efforts at promotion. Getting FDI in technologically advanced or export-oriented activities is even more demanding.

Having attracted foreign investors into a country, policies are crucial to ensure that FDI brings more benefits. Policies can induce faster upgrading of technologies and skills, raise local procurement, secure more reinvestment of profits, and protect the environment and consumers and so on. They can also help counter the potential dangers of FDI say, by containing anti-competitive practices and preventing foreign affiliates from crowding out viable local firms or acting in ways that upset local sensitivities.

The economic attractiveness of a country for FDI depends primarily on its advantages as a location for investors of various types. Market-seeking investors look for large and growing markets. Resource-seeking ones look for ample nature resources. And efficiency-seeking ones look for a competitive and efficient base for export production.

More general factors affect all prospective host economies, political stability, a sound macro-economic framework, welcoming attitudes to foreign investment, adequate skills, low business transaction costs, good infrastructure and the like (Table 3).

Free markets do not always ensure efficient and equitable outcomes, particularly in developing countries with weak markets and institutions. Hence,

Table 3: Host country determinants of FDI

I. Policy framework for FDI		
Economic, political and social stability		
Rules regarding entry and operations		
Standard of treatment of Foreign affiliates		
Policies on functioning and structure of markets (especially competition and M&A policies)		
International trade and investment agreements		
Privatization policy		
Trade policy (tariffs and non-tariff barriers) and coherence of FDI and trade policies		
Tax policy		
II. Economic determinants Types of FDI classified principal economic determinants by motives of TNCs in host countries		
A. Market-seeking	**B. Resource/ asset-seeking**	**C. Efficiency-seeking**
a. market size and per capita income b. market growth c. access to regional and global markets d. country-specific consumer preferences e. structure of markets	a. raw materials b. low-cost unskilled labour c. skilled labour d. technological, innovatory and other created assets (e.g. brand names), including as embodied in individuals, firms and clusters e. physical infrastructure (ports, roads, power, telecommunication)	a. cost of resources and assets listed under B, adjusted for productivity for labour b. other input costs, e.g. transport and communication costs to/from and within host economy and costs of other intermediate products c. membership of a regional integration agreement conducive to the establishment of regional corporate networks
III. Business facilitation		
a. investment promotion (including image building and investment-generating activities and investment-facilitation services)		
b. investment incentives		
c. hassle costs (related to corruption, administrative efficiency, etc.)		
d. social amenities (bilingual schools, quality of life, etc.)		
e. after-investment services		

Source: World Investment Report 1998, Pg. 91.

Table 4: China and India: selected FDI indicators, 1990, 2000-2002

Item	Country	1990	2000	2001	2002
FDI inflows (Million dollars)	China	3487	40772	46846	52700
	India	379	4029	6131	5518
Inward FDI stock (Million dollars)	China	24762	348346	395192	447892
	India	1961	29876	36007	41525
Growth of FDI inflows (annual %)	China	2.8	1.1	14.9	12.5
	India	-6.1	16.1	52.2	-10.0
FDI stock as percentage of GDP (%)	China	7.0	32.3	33.2	36.2
	India	0.6	6.5	7.4	8.3
FDI flows as percentage of gross fixed capital formation (%)	China	3.5	10.3	10.5	N.A
	India	0.5	4.0	5.8	
FDI flows per capita (Dollars)	China	3.0	32.0	36.5	40.7
	India	0.4	4.0	6.0	5.3
Share of foreign affiliates in total exports (%)	China	12.6	47.9	50.0	NA
	India	4.5	NA	NA	
GDP (billion dollars) a	China	388	1080	1159.1	1237.2
	India	311	463	484	502
Real GDP growth (%)	China	3.8	8.0	7.3	8.0
	India	6.0	5.4	4.2	4.9

Source: UNCTAD, FDI/TNC database; IMF, World Economic Outlook Database, April 2003.

the need for policy intervention. The ground work for making markets work well – sound legal systems, clear and enforceable rules of the game, responsive market institutions, a vibrant domestic enterprise sector and the like – has to be laid down by the host country government. But even then, the strategic objectives of TNCs may not match the development goals of host governments. Policies need to bring them more in line with those goals.

The IMF definition of FDI includes as many as twelve different element-equity capital reinvested earning of foreign companies, inter-company debt transactions, short-term and long-term loans, financial leasing trade credits grants bonds, on-cash acquisition of equity, investment made by foreign venture capital investors, earning data of indirectly held FDI enterprises, control premium and non-competition fee. Until recently, Indian data on FDI did not include any other element other than equity capital reported on the basis of issue or transfer of equity or preference shares to foreign direct investor. China on the other hand, includes all these in its definition of FDI. China also classified imported equipment as FDI, whereas India includes these as imports in its trade data. After the incorporation of new items, FDI inflow into India during 2001-02 were revised upwards by US$ 1.7 billion and US $ 2.2 billion, respectively. However, even after adjusting for round tripping in China and considering the new FDI data for India at US$ 6 billion, respectively in 2001, FDI continues to remain considerable. In this context, it is also important to point out that India receives large private transfers in the forms of remittance inflows from non-residents and also capital inflow in the form of NRI deposits. In recent times, gross workers' remittances to India per annum have been around US$ 3 billion. Inflow to China from Chinese Diaspora, on the other hand, is recorded largely as FDI. Recent literature suggests that domestic market size is a major factor in including FDI inflow (IMF, 2003). At present, the Chinese economy is two-and-a-half times that of the Indian economy while per capita income is twice as high. The growth induced local demand for durables and non-durables, competitive business environment, wage-adjusted productivity of

labour, higher literacy, better infrastructure and education rates drive the efficiency seeking investors to China (UNCTAD, 2003). FDI in China is also driven by 'peer pressure' since many firms have followed their competitors into China to pressure their significant investment in mainland China. The overseas network and investment in India are much smaller (Bhalla, 2002).

On the basis of economic determinants of inward FDI, China does better than India. China's total and per capita GDP are higher making it more attractive to efficiency-seeking investors (World Bank 2003c, p. 234; UNDP 2002). China also has large natural resource endowments. In addition, China's physical infrastructure is more competitive, particularly in the coastal areas (CUTS 2003, Marubeni Corporation Economic Research Institute 2002). But, India may have an advantage in technical manpower, particularly in information technology. It also has better English language skills.

Some of the differences in competitive advantages of the two countries are illustrated by the composition of their inward FDI flows. In information and communication technology, China has become a key centre for hardware design and manufacturing by such companies as Acer, Ericsson, and General Electric-Hitachi Semiconductors, Microsoft, Mitac International Corporation, Motorola, NEC, Nokia, Philips, Samsung Electronics, Sony, Taiwan Semiconductor Manufacturing, Toshiba and other major electronics TNCs. India specializes in IT services; call centres, business back-office operations and R&D.

Rapid growth in China has increased the local demand for consumer durables and non-durables, such as home appliances, electronics equipment, automobiles, housing and leisure. This rapid growth in local demand, as well as competitive business environment and infrastructure, has attracted many market-seeking investors. It has also encouraged the growth of many local indigenous firms that support manufacturing. Other determinants related to FDI attitudes, policies and procedures also explain why China does better in attracting FDI. China has "more business-oriented" and more FDI-friendly policies than India (AT Kearney 2001). China's FDI procedures are easier, and decisions can be taken rapidly.

China has more flexible labour laws, a better labour climate and better entry and exit procedures for business (CUTS 2003). A present business environment survey indicated that China is more attractive than India in the macro-economic environment, market opportunities and policy towards FDI. India scored better on the political environment, taxes and financing (EIU 2003a). In India the Government has planned to open some more industries for FDI and further relax the foreign equity ownership ceiling (EIU 2003a). To identify approaches to increase FDI flows, the Planning Commission established a steering committee on FDI in August 2001. Following the Chinese model, India recently took steps to establish special economic zones. China's special economic zones have been more successful than Indian export processing zones in promoting trade and attracting FDI (Bhalla 2002).

Both China and India are good candidates for the relocation of labour-intensive activities by TNCs, a major factor in the growth of Chinese exports. In India, however, this has been primarily in services, notably information and communication technology. Indeed, almost all major United States and European information technology firms are in India, mostly in Bangalore. Companies such as American Express, British Airways, Conseco, Dell Computer and GE Capital have their back-office operation in India. Other companies such as Amazons Com and Citigroup outsource services to local or foreign companies already established in the country. Investor's sentiment on China as a location for investment is improving. Nearly 80 per cent of all Fortune 500 companies are in China, while 37 per cent of the Fortune 500 outsource to India (NASSCOM 2001). Despite the improvement, TNC investment interest remains lukewarm, with some exceptions, such as in information and communication technology (AT Kearney 2001).

The prospects for FDI flows to China and India are promising, assuming that both countries want to accord FDI a role in their development process. The large market size and potential, the skilled labour force and the low wage cost will remain key attractions. China will continue to be a magnet of FDI flows and India's biggest competitor. But, FDI flows to India are set to rise, helped by a vibrant domestic enterprise sector and if policy reforms continue and the Government is committed to the objective of attracting FDI flows to the country.

Towards a strategic FDI policy

Liberalization of norms relating to FDI and adoption of a policy stance supportive of globalization do not by themselves ensure that the economy would attain a high growth path. On the contrary, such policies could, in fact, be inimical to the long-term development process of the country in the absence of 'safeguards'. If FDI is to be utilized for sustaining growth process of a country, it is essential to create local technological capabilities. The success of an industry in a global scenario hinges

Table 5: Technology import strategies, policies and conditions

Strategy objective	Policy	Policy instruments	Condition
Promote domestic technological capabilities by minimizing reliance FDI	Conditions on FDI	Foreign ownership restrictions	Exposure to international competition (as by strong export orientation)
	Incentives to partnership agreements	Financial and tax incentives to local firms	Availability of skilled labour
	Government support to domestic firm	Technical support, R&D promotion programmes	Financial resources
	Foster national flagship firms	Effective export promotion	Entrepreneur's willingness and ability to undertake risky technological investment
		Encourage hiring of foreign experts, licensing and capital goods imports	Institutions able to support skill, technology and export activity.
Promotion of FDI with minimal government intervention in the expectation that it will involve technology transfer	Encourage large FDI inflows	Remove FDI restrictions or provide incentives	Efficient and credible institutions to administer market–friendly policies
	Relax FDI restrictions	Relax FDI restrictions	High local absorptive capacity.
	Ensure macro-economic stability	Foster competition and well-structured IPR regimes	
		General FDI promotion	
Promote technology transfer by FDI with proactive government intervention	Target specific TNCs	Industrial park and advanced infrastructure	
	Provide incentives for TNCs to upgrade their technologies	Well-structured IPR regimes	
		High level skills and strong training system geared to activities promoted	
		Rigorous quality standards	
Mixed strategy	Promote linkage with domestic economy	Business incubators	Institutions able to bargain with TNCs
		Information clearing houses	Institutions able to plan strategically
	Build local techno-logical capabilities	Industrial parks	Ability to integrate skills, financial markets, infrastructure and technological capability development
	Encourage deepening of TNC activity	Supporting R&D	
		Supporting joint ventures, licensing and collaboration	
		Supporting training of domestic labour force	

Source: Adapted from WTO 2002a.

on its capacity to effectively cope with technical change. Skill development, industrial specialization, enterprise learning and industrial restructuring lead to improvement in productivity and help industries to cope with technical change. In order to create such processes within an economy, the Government may need to formulate a strategic FDI policy. A strategic FDI policy entails Government intervention in factor markets in order to develop local skills and to target FDI in areas where the country has a dynamic comparative advantage (UNCTAD, 2003). The policy of the Govt. should be aimed at reducing macro-level ineffectiveness and improving micro-level conditions. The Government should be an effective regulator, being neutral to domestic and foreign capital.

The success of an industry in a global scenario hinges on its capacity to effectively cope with technical change.

The effectiveness of a strategic FDI policy is, however, not much in significance now and it is almost a settled issue. Still, some studies suggest that Government intervention aimed at affecting FDI flows is at best ineffective and could be counterproductive. It is observed that direct foreign investors were not included by incentives such as tax concessions or strengthening the

economic fundamentals of the host economy. It has also been argued that industrial policies that seek to direct foreign investment flows towards certain sectors only distort the normal functioning of the market. While such measures do not include FDI, these can have serious negative implications in the form of reduced competition and creation of excess capacity in certain sectors (McKinsey Global Institute, 2003).

The motivation and determinants of FDI differ among countries and across economic sectors. These factors include:

(a) the policy framework such as, international trade and investment agreements, trade policy (tariff and non-tariff barriers) and coherence of FDI policies etc.

(b) the extent of business facilitation and other economic determinants such as macroeconomic fundamentals like market size and per capita income, access to regional and global markets etc. and availability of infrastructure like, raw materials, low-cost unskilled labour, skilled labour, technological, innovative and other creative assets, (i.e. brand names) including as embodied in individuals firms and clusters, physical infrastructure (ports, roads, power, telecommunication)

(c) business facilitation such as investment promotion (including image-building and investment-generating activities and investment facilitation services), investment incentives, hassle costs (corruption, administrative efficiency, etc.), social amenities (bilingual schools, quality of life, etc.), alternate investment services.

The Emerging Challenges

The most important challenge for developing countries with regard to International Investment Agreements (IIAs) is to increase FDI flows and the ability of countries to pursue development – oriented FDI policies, as an expression of their right to regulate in the public interest. This requires maintaining sufficient policy space to give governments the flexibility to use such policies within the framework of the obligations established by the IIAs. The tension this creates is obvious. Too much policy space impairs the value of international obligations. Too stringent obligations overly constrain the national policy space. Funding a development – oriented balance is the challenge. When negotiating IIAs, the objectives of IIAs, their structure, content and implementation is addressed. Their content is central, as the quest for a development-friendly balance plays itself out in the resolution of issues that are particularly important for the ability of countries to pursue development – oriented national FDI policies and that are particularly sensitive in international investment negotiations, because countries have diverging views about them in light of their own predominating objectives.

From a development perspective, the most important issues are the definition of "investment", because it determines the scope and reach of the substantive provisions of an agreement; the scope of national treatment (especially as it relates to the right of establishment), because it determines how much and in which ways preference can be given to domestic enterprises; the circumstances under which government policies should be regarded as regulatory takings, because this involves testing the boundary line between the legitimate right to regulate and the rights of private property owners; the scope of dispute settlement, because this raises the question of involvement of non-state actors and the extent to which the settlement of investment disputes is self-contained and the use of performance requirements, incentives, transfer-of-technology policies and competition policy, because they can advance development objectives. For each of the issues, more development-friendly and less development-friendly solutions exist. From the perspective of many developing countries, the preferable approach is therefore a broad GATS-type positive list approach that allows each country to determine for itself for which of these issues to commit itself to in IIAs, under what conditions, and at what pace, commensurate with its individual needs and circumstances. In pursuit of an overall balance, furthermore, future IIAs need to pay more attention to commitments by home countries. In fact, all developed countries (the main home countries), out of their own self-interest, already have various measures to encourage FDI flows to developing countries. And a number of bilateral and regional agreements contain commitments. Developing countries would benefit from making home country measures more transparent, stable and predictable in future IIAs.

Transnational Corporations (TNCs) too can contribute more to advancing the development impact of their investment in developing countries, as part of good corporate citizenship responsibilities, whether through voluntary action or more legally based processes. Areas particularly important from a development perspective are contributing fully to public revenues of host countries; creating and upgrading linkages with local enterprises; creating employment opportunities; raising local skill levels; and transferring technology. These issues are all complex. Because the potential implications of some provisions in IIAs are not fully known, it is not easy for individual countries to make the right choices.

The complexities and sensitivities are illustrated by the experience of NAFTA for the regional level; that of the IIA negotiations for the interregional level and that of the GATS and TRIMs Agreement for the multilateral level. Given the evolving nature of IIAs, other complexities tend to arise in applying and interpreting agreements. Indeed, disputes may arise from these processes, and their outcome is often hard to predict. That is why Governments need to ensure that such difficulties are kept to a minimum, by including appropriate safeguards at the outset to clarify the range of special and differential rights and qualification of obligations that developing country parties might enjoy. Moreover, the administrative burden arising from new commitments at the international level is likely to weigh disportionately on developing countries especially the least developed, because they often lack the human and financial resources needed to implement agreements. This underlines the importance of capacity-building technical cooperation to help developing countries assess better various policy options before entering new agreements and implementing the commitments made.

The overriding challenge for countries is to find a development-oriented balance when negotiating the objectives, content, structure, and implementation of future IIAs at whatever level and in whatever context. The development dimension has to be an integral part of international investment agreements in support of national policies to attract more FDI and to benefit more from it. Most developing countries consider FDI an important channel for accessing resources for economic development. FDI represents transfer of a bundle of assets like capital, technology, access to exports markets, skills and management techniques and modern environmental management systems.

Conclusion

There has been significant liberalization of FDI policies over the past decade. Still FDI is only a complement to domestic investment and even when inflows rose, the development benefits of FDI were often below expectations of the recipient domestic country. In essence, the actual impact of capital flows on economic growth is undoubtedly an empirical issue and varies widely across countries. An increase in capital flows is expected to augment domestic saving/investment, boost aggregate demand and lead to an increase in aggregate output/income. At the same time, capital flows induced appreciation of exchange rate could adversely affect exports and increase imports thereby dampening the impact on aggregate demand, and lead to a deterioration in the current account. The policy response to the loss of external competitiveness may entail a softer interest rate environment to prevent appreciation of the exchange rate and to strengthen growth prospects.

Notwithstanding their potentially favourable impact on growth prospects, the highly volatile nature of capital flows, especially portfolio flows and short-term debt, underscores the need for efficient management of these flows. While managing capital flows, clear distribution should be made between debts and non-debt creating flows, private and official flows and short-term and long-term capital flows. An overbearing objective of external sector policies of developing countries has been to devise strategies so as to maximize the benefits of capital inflows while limiting their adverse impact. At an individual country level, an appropriate response would be to build a resilient and robust financial sector which could appropriately boost large capital flows. It is imperative that such capital flows are absorbed smoothly in real sector embodying growth impulses. Adoption of proper macroeconomic policies, particularly in respect of exchange rate management and monetary stance, also assumes significance in dealing with large capital flows.

The experience of the Asian crisis revealed that large and volatile capital flows influences the exchange rates and interest rates, leading thereby to overshooting of exchange rates in some cases, as expectations and reactions to new drove capital flows and exchange rates often out of alignment with fundamentals. Policy makers in developing countries, therefore, have to manage their capital accounts to ensure an orderly process of liberalization. The success of policy would lie essentially in managing the flows to reduce their volatility and limit their negative impact while reaping the benefits of such flows to enhance growth prospects of the economy.

To conclude, the need for a strategic FDI policy depends on several issues, because, once an enabling framework has been established, economic factors – the main determinants of FDI flows – assert themselves the extent of capital flows. On the contrary, host countries may not have the size of markets, growth rates, capabilities or infrastructure that would make investment in productive capacity attractive – either for the domestic market or as export base. Foreign investors may not have been well informed of the opportunities available – perhaps because host countries did not promote themselves effectively in an intensely competitive world market for FDI or were ambiguous about how much FDI they really wanted and on what terms.

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Growth that adds volume without improving productivity is fat. Growth that diminishes productivity is cancer.

– Peter Drucker

Feature

Sectoral Water Needs in a River Basin—The Case of Amaravathy River Basin, Tamil Nadu

P. Paramasivam

River basins as the geographical planning units for water resource management are gaining currency globally. This paper examines water use in the Amaravathy sub-river basin of Tamil Nadu, both at present and in the future, and offers certain policy options.

P. Paramasivam is Associate Professor, Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore.

Population and economic growth in developing countries will pose serious challenges for humanity in simultaneously meeting food requirements and water demands. Competition for limited water resources increasingly occurs between different stakeholders and at different levels: between farmers within an irrigation system; between irrigation systems in the same river basin; between the agricultural sector and other rural uses, such as fisheries or domestic water supply and drinking water; and more and more between agricultural and urban and industrial users and uses; and environmental uses (for example, in stream flows and recreation).

Agriculture still accounts for the majority of global water withdrawals, and is often responsible for 80 per cent or more of total withdrawals for consumptive uses in developing countries, but, it is likely that significant amounts of water will be reallocated from agricultural uses to higher valued domestic and industrial water demands.

Globally, the basin level water planning has been accepted to be the most logical way of managing available water resources. Growing non-agricultural water needs exert greater pressures on the agricultural sector to forgo its former share. Increasing the water use efficiency, with reductions in wastages and water recycling are required in all water using sectors to match the supply and demand. Proactive assessment of the growing water needs in a holistic perspective and anticipatory planning to manage and sustain water supply have become imperative. Though extensive literature is available on water use covering its various dimensions, only limited basin level studies are available assessing the match between supply and demand for the present and future. This paper presents the results of the study undertaken in the Amaravathy river basin regarding the intersectoral water allocation among different water using sectors and the likely balance between supply and demand in the near future.

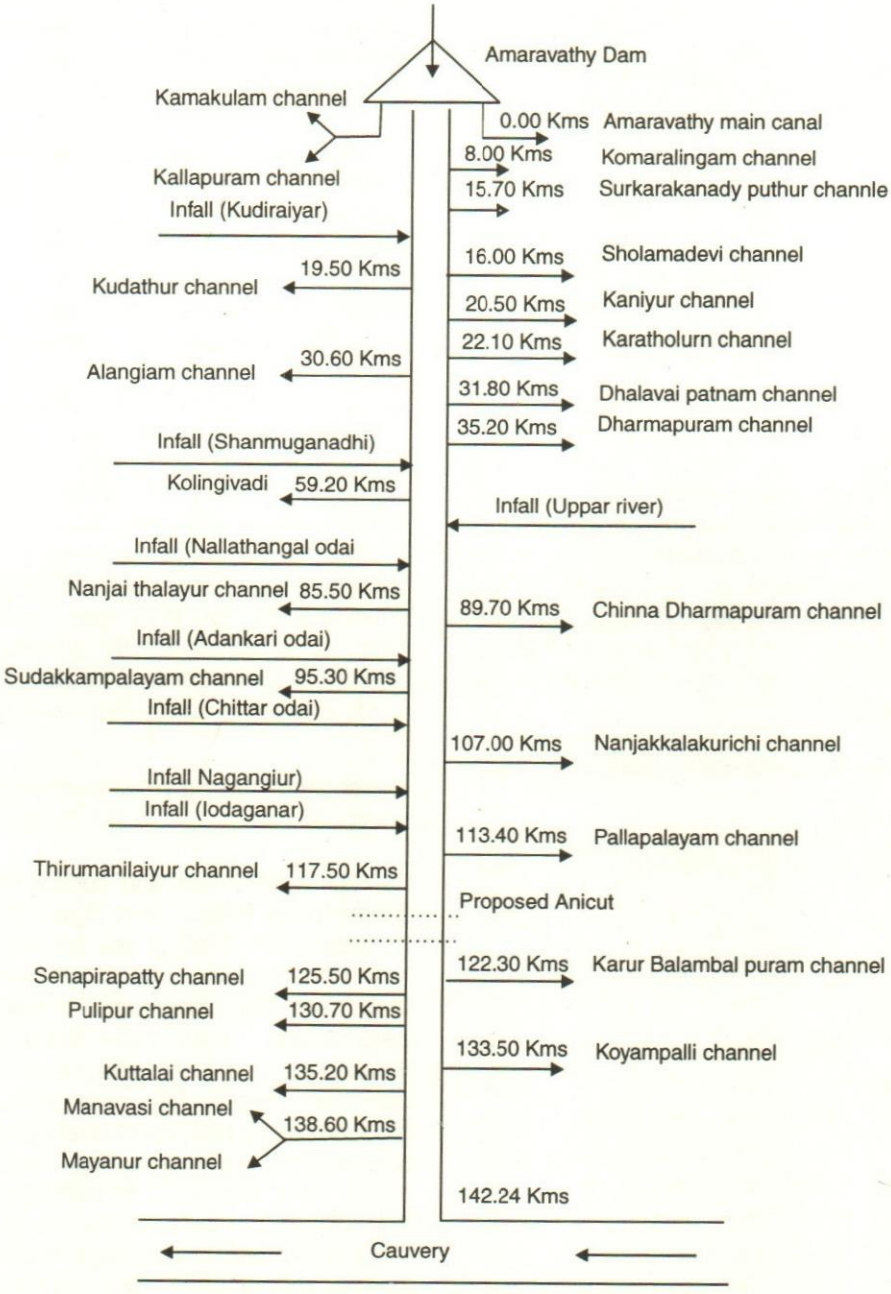

Fig. 1. Flow Diagram of Amaravathy River System

Amaravathy River Basin Irrigation System

Amaravathy river basin is a sub basin (Figure 1) of the Cauvery river basin of Tamil Nadu State. Amaravathy river originates in the western slopes of Moonar hills of Kerala and is one of the main tributaries to Cauvery. It traverses a length of 192 Kms, and joins Cauvary in 142.24 Kms at Thirumukudal near Manyanur in Karur. It covers Coimbatore, Dindugal, Erode and Karur Districts of the state. Amaravathy is perennial and is fully utilised throughout its course. It has its own tributaries viz, Kuthiraiyur, Shanmuganathi, Uppar river, Nangangi river, and Kodaganar river that also originate from the Western Ghats. The irrigation system consists of the traditional old command system and the new command created after the construction of a dam across the river.

The old command system is served by 25 irrigation channels tacking off from 15 anaicuts, one masonry korambu and six mud korambus temporarily formed in

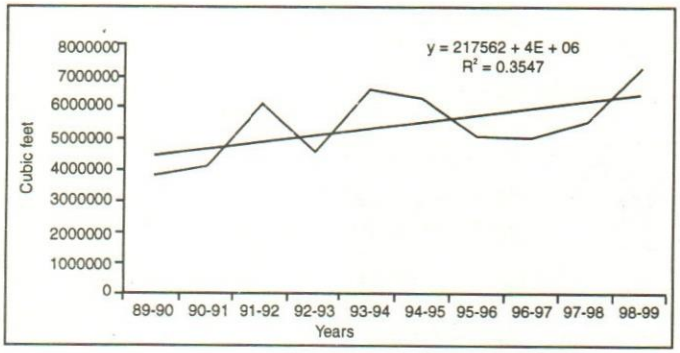

Fig. 2. Water drawn by All Industries

every crop season. The command area under the old system is 11,893 hectares of double crop paddy. Ramakulam and Kallapuram, the two riparian canals forming part of this system, separately off take from Amaravathy river at the dam. Command area under the old system extends up to the confluence of Amaravathy river with Cauvary, and covers a narrow strip on both sides of the river, i.e. about 5990 hectares fed by 12 channels on the left side and a command of 4755 hectares on the right side. The canal system serving the old command is unlinked.

Table 1: Water inflow and outflow details in Amaravathy basin (in mcft)

Year	Water inflow	River release	AMC release	Kallapuram Ramakulam channel	Sluice leakage	Evaporation	Total inflow (Adjusted)
89-90	17267	6830	4985	1193	3517	387	16912
90-90	10643	7183	2151	1102		270	10706
91-92	11703	7415	3313	783		220	11731
92-93	18694	7503	4932	1076	5171	354	19036
93-94	22648	6473	4347	1264	9947	342	22373
94-95	17125	5717	4274	1294	5856	327	17468
95-96	10373	5079	2299	1151	1822	191	10542
96-97	15476	3919	3797	1307	5800	417	15240
97-98	19528	5701	4078	919	8704	352	19754
98-99	19411	7963	4035	1140	5964	339	19441
99-2000	17197	5009	3551	1321	7094	313	17288
Average	16369.55	6253.82	3796.55	1140.91	5986.11	319.27	16408.27
Average (%)	99.76	38.11	23.14	6.95	36.48	1.95	100.00

Amaravathy Reservoir lies 335 metres above MSL and was commissioned in 1958-59. The project envisaged stabilizing the then existing 11893 hectares and creating additional facilities to irrigate about 8875 hectares. The dam is of composite masonry and earthen type with a live storage of 110 MCM. At 75 per cent dependability the reservoir gets three fillings in a year. The reservoir inflows from southwest monsoon are not materially different from those of northeast monsoon. Both monsoons contribute equally to the inflows. However, the command area receives substantially more rainfall during the northeast monsoon than in southwest monsoon.

Amaravathy new Command comprising mainly the Amaravathy main canal (AMC) was excavated on the left bank of the river, having its head sluice in the left flank of the dam. This is a contour canal and the command area is distributed in Udumalaipet and Dharapuram taluks. Amaravathy main canal has been designed for a capacity of 8.495 cumecs to irrigate an extend of 8875 hectares of single crop at duties of 0.7 l/s/ha, for 7255 hectares of dry crop at 0.92 l/s/ha, for 1215 hectares of sugarcane at 1.15 l/s/ha and for 405 ha of paddy crop subject to the condition that the drawl of water from Amaravathy main canal should not exceed 8.213 cumecs including 25 per cent for transmission losses. The length of the canal is about 62.80 kms and was not lined. During 1982-84 the entire main canal was lined except for 8.80 kms, enhancing its carrying capacity to about 13.592 cumeces with the indented additional water delivery to about 1305 hectares of dry lands extending from head to tail reaches.

Water storage and release details from Amaravathy reservoir

The water inflow and outflow data from the reservoir presented in Table 1 (and Figure 2) indicate that there is no significant trend in the inflows and outflows to the river and channels over time. The trend lines indicate that these flows have almost been constant over the past decade. There have been fluctuations over the years around a long term trend and by and large the outflows seem to follow the pattern of inflows. There have not been significant changes in the water distribution system to the irrigation sector. Water is released based on predefined crop acreage and water duties and the release is made on the basis of inflows. Decadal flows in the reservoir average about 16408 mcft of which an average of 5986 mcft (36.5%) is lost to the river through surplus weirs and sluice leakage. River release accounts for about 6254 mcft (30%) and AMC release for about 37 97 mcft (23.14%). The reparian dam level canals (Kallapuram and Ramakulam) account for 1141 mcft (6.95%) with about 319 mcft (1.95%) lost through evaporation.

Assessment water distribution

Approach

Analysis of intersectoral water distribution can be

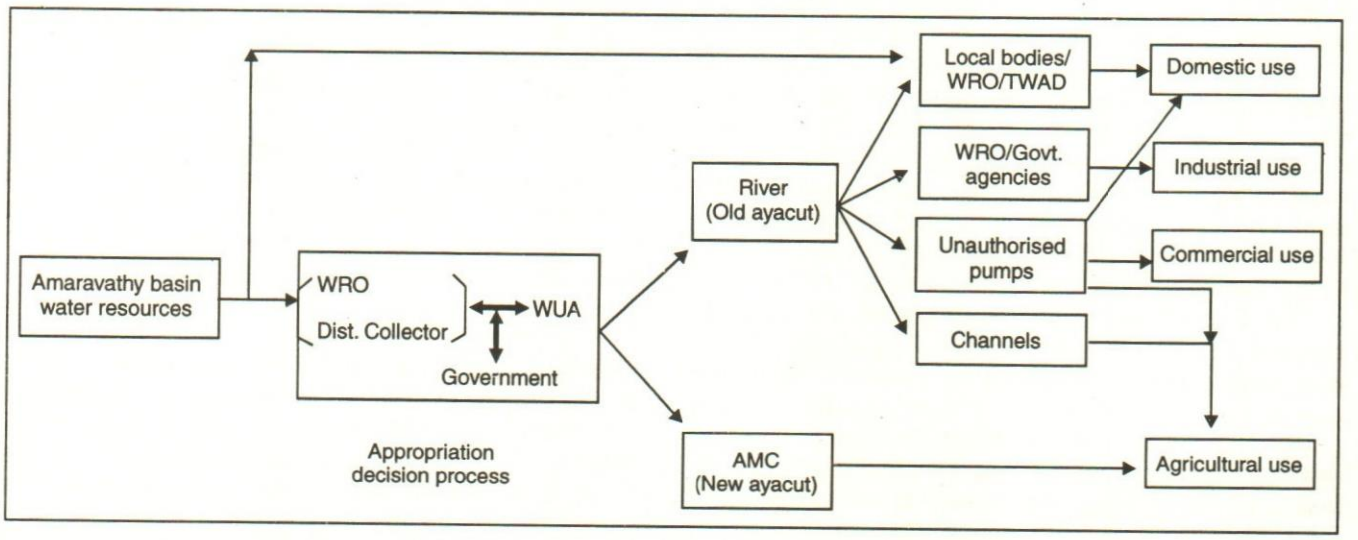

Chart 1. Water use and stakeholders in Amaravathy basin

panchayats and municipalities conceive and implement drinking water schemes. Other than that they interact with the Tamil Nadu Water and Drainage (TWAD) board, which builds and transfers the schemes to the former.

Industrial users approach the government through WRO and get individual appropriation orders for specific periods, subject to renewal of drawal permits and other terms and conditions. The operational details, contracts and collection of charges are handled by WRO. In most cases, when industries satisfy procedural requirements including Pollution Control Board (PCB) clearance, they get their request sanctioned. As of now, approval of industrial appropriation seems not to have been considered in the context of the agricultural sector loosing its share.

There is no separate category of commercial establishments formally recognized and approved to draw water from the Amaravathy basin system. However, there are certain establishments like hotels, marriage halls, automobile service stations, construction concerns, small-scale dying and bleaching units that use large quantities of water but do not constitute industries. These sections are considered as commercial water users in this study. Local bodies through their drinking water schemes serve some of these units. But most of these establishments have to manage their requirements either through developing their own groundwater sources or have to look for other sources. Construction concerns and small-scale bleaching and dying units (requiring large quantities of water) need other sources of water supply. It is here that unauthorized pumping from the river source and water transportation through tankers and sales play a major role. Apart from the needs of commercial establishments, some of the domestic water needs, especially in urban peripheral areas where drinking water supply networks are yet to be created, are also met from these sources. Even where water supply networks exist, tankers and water sales serve during scarcity periods.

Agricultural water users, though assured of second priority as a matter of policy, in reality have to be contented with whatever is left after appropriation either legally or unauthorized to domestic, industrial and commercial users. As far as domestic users, their priority is accepted and drawal sanctioned or taken for granted. Industrial users are normally permitted to draw water without much reference to agricultural use, when they satisfy other procedural requirements. Commercial users get their water from unauthorized sources that thrive in the absence of concerted administrative action. Thus the water use management of the Amaravathy basin can be schematically represented in chart 1.

The major stakeholders are domestic, agricultural, industrial and commercial sectors, government departments WRO, TWAD board, PCB, and the water user's associations both formal and informal.

Existing distribution

Major appropriation decision of the Amaravathy basin water relates to its distribution between the old ayacut area represented by the river delivery system, and the new ayacut area represented by the modern AMC delivery system. This distribution is decided by an interaction process among the WRO, District Collectors and farmers representatives and is formally approved by the government. The operational details,

approached in a positive or normative paradigm. Positive approach essentially attempts to assess what exists at the field level. It involves extensive surveys of the sources of the sources of water, its storage and management dynamics, distribution mechanisms, decision making and implementing institutions and administrative machinery and the sectoral stakeholders themselves who interact in the system in various ways. It is viewed as a flexible system, continuously evolving to suit emerging local needs. No rigid a priori theoretical or logical structure is imposed to explain the organisation and functioning of the system. If at all, the attempt is to study various components of the system and their operational interactions and to formalise them into a model inductively. The advantage claimed is that one does the job of understanding the system without imposing any value judgments regarding the desirability of the system or its sub-systems. The criticism is that it does not provide for planning guidelines. Only the objectives determine the criteria against which planning and achievements could be contrasted and compared. In an irrigation system like Amaravathy, objectives inherently lead to conflicts among stakeholders.

Recent developments favour a movement towards market economy. Developing water markets to take care of distributional issues is being advocated in various quarters. It is projected as an effective alternative to the exiting social distribution, which is considered to be no distribution system at all by some economists. It is argued that by moving into the market realm and pricing of water use, all distributional issues could be sorted out in the market place by the stakeholders. The vastly developed, highly sophisticated neo-classical tools are readily available for analysing the issues if one accepts the free market paradigm for water resource management.

Once water is considered an economic good under market direction, its distribution is determined by its marginal productivity in different sectors and uses in combination with output prices. Marginal productivity of water in value terms will be higher in sectors where the products are in high demand. Thus water would flow across sectors to level its productivity. Analytically one can easily define a set of sectoral production functions (of goods or services) with water as an input, and solve the optimal water distribution among sectors by equating the value of marginal productivities of water across sectors.

One critical factor necessary for water resource to come under market economy, is the existence and enforcement of property rights, with related properties of transferability, enforceability, exclusion etc. This is a complex issue with respect to at least surface water, if not groundwater where the issue is indirectly taken care of by its association with property rights on land. Creation and enforcement of market economy order are thus associated with enormous efforts to define socio-political-legal conceptualisations of water resource use in a hitherto radically different perspective. The entire range of sectors using water need to update themselves regarding the marginal productivities of water in their respective sectors, which means the entire set of production activities need to be monetised.

Considering the totality of the circumstances described above, it is considered that, for the time being all the stakeholders or water users in the Amaravathy basin have not got the means to operate under market direction. The older social economy whatever it may mean, is still and for years to come, the practical reality though there are some efforts on the fringes to reform the system to accept market economy. Existing pattern of water usage has been determined by the social benefit policies of perceived socialistic order, and is likely to continue with similar trends. Accordingly first an attempt is made to assess the operation of the existing Amaravathy basin system followed by attempts to project the sectoral water distribution in the near future.

To carry out the objectives of the study, extensive efforts were undertaken to collect data from concerned stakeholders through field surveys using pre-designed questionnaires. Major stakeholders in terms of water user groups are the domestic, industrial, commercial and agricultural sectors. Others are the field functionaries of the Water Resource Organisation (WRO) entrusted with the operation and maintenance of the Amaravathy basin water delivery system, the village Administrative Officers of the basin, unauthorized pump set operators and water transporters. From the data and information gathered broad contours of water management in the Amaravathy basin system could be delineated.

Stakeholders and Management

The rights over water use are a complex issue with riparian and other rights, but by default its appropriation vests with the government. Appropriations of Amaravathy basin water is supposedly managed by the WRO under the authority of the Government of Tamil Nadu. In practice the appropriation is decided by a complex socio-political and bureaucratic interaction process. The water policies of the state and country define the broad contours of the sectoral allocation, with domestic uses getting the top priority followed by agriculture, industry and other uses. In actual practice, drinking water schemes are given priority and are approved and implemented as and when decided by appropriate agencies. Local bodies like

rules and past release details are presented in Tables 2-4.

Water Release-Operational details

Normally water release for the old ayacut area is from June Ist to March 31st and irrigated area is 29,387 ac. For new ayacut water release is from August 1st to January 31st and irrigated area is 25,250 ac.

Once the distribution decision is made, the AMC solely serves the agricultural users. Further distributional complexities occur only in the river delivery system. Industries get their allocation as decreed by the government mediated by related government agencies. Unauthorized pump sets appropriate water on their own accord from the river delivery and serve almost all water using sectors; domestic, commercial and agricultural, except perhaps the industrial sector. Remaining water reaches agricultural users through the river delivery system.

Within the road map of the Water Amaravathy basin system, there is thus appropriation and distribution decisions involved which affect user sectors differently. There are issues of management, control, organisation and implementation of the decisions, and issues of conflict potentials among user sectors. Growth and development in individual water using sectors is likely to add to these issues. It therefore becomes essential to assess the existing patter of water allocation, the likely growth in water needs of different sectors in the future, to understand the existing organisational and institutional strengths and weaknesses and to understand the present perspectives and future expectations of the user sectors.

Table 2: Opening and closing dates: River

Year	As per rules (date)		Actual (date)		Storage as on opening date (mcft)
	opening	closing	opening	closing	
1995-96	June Ist	March 31st	10.6.95	12.1.96	
1996-97	June Ist	March 31st	17.6.96	31.3.97	
1997-98	June Ist	March 31st	7.6.97	26.4.98	
1998-99	June Ist	March 31st	4.7.98	3.2.99	2552.27
1999-00	June Ist	March 31st	16.8.99	12.3.00	1607.21
2000-01	June Ist	March 31st	30.6.00	27.3.01	613.88

Existing drawal for domestic uses

Along the river course local bodies like panchayats and panchayat unions increasingly resort to drawing

Table 3: Opening and closing dates: AMC

Year	As per rules (date)		Actual (date)		Special wetting		Storage as on opening date (mcft)
	opening	closing	opening	closing	opening	closing	
1995-96	Aug Ist	Jan 31st	3.8.95	23.12.95			
1996-97	Aug Ist	Jan 31st	17.7.96	1.8.96	7.7.96		
1997-98	Aug Ist	Jan 31st	15.8.97	4.4.98			
1998-99	Aug Ist	Jan 31st	1.8.98	23.2.99			349.92
1999-00	Aug Ist	Jan 31st	1.11.99	25.3.00	4.8.99	19.8.99	3818.75
2000-01	Aug Ist	Jan 31st	11.9.00	29.1.01	28.7.00	12.8.00	3808.57
2001-02	Aug Ist	Jan 31st			28.5.01	4.6.01	

Table 4: 1998-99 to 2000-01—Water release particulars in Old and New ayacut areas.

Year	Old ayacut		AMC		Total	
	cusecs	mcft	cusecs	mcft	cusecs	mcft
1998-99	1,32,334	11433.65	46,755	4,039.60	1,79,089	15,473.29
1999-00	1,13,176	9778.41	41,098	3550.87	1,54,274	13,329.27
2000-01	1,24,507	10,757.40	41,637	3597.18	1,36,144	14,354.84

Note: Amaravathy Dam comes under II class dam. As per G.O. 1116/P.W.D. dt. 21.7.77 water release for AMC discussed with Commissioner of Food production and reports submitted to the Government and gets G.O. and water released. For Old command area water release decided based on discussion with district collectors of Coimbatore, Erode and Karur districts.

water from the river course through pumping schemes for drinking purposes. Though procedures exist to regulate such water withdrawal, the local bodies do not seem to follow them scrupulously. In any case except sketchy data on some of the withdrawal points, not much data on the quantum of water drawn by these agencies seem to be available in a systematic manner. The overall drawal of water from the Amaravathy basin as per the tapping points and drinking water schemes described above are as in Table 5.

Table 5: Domestic water use details

Sl. No.	Name of the Scheme	Litres/day
1	Manupatti – Tothipalayam Joint water supply scheme (from reservoir)	1,840,000
2	Amaravathi PWD section office (from reservoir)	200,000
3	Kumaralingam C.W.S.S.	1,000,000
4	Sankaranallur C.W.S.S.	650,000
5	Madathukulam (TP) and 22 wayside habitations (new scheme)	5096,000
6	Madathukulam water supply scheme	780,000
7	Kaniyur water supply	400,000
8	Karatholuvu water supply	100,000
9	Kadathur water supply	150,000
10	Solamadevi water supply	60,000
11	Tamaraipadi and other habitations	1,320,000
12	Dhalavai pattinam water supply	150,000
13	Alangium water supply	100,000
14	Dharapuram Town panchayat water supply	4,400,000
	Total	16,246,000

Thus from the collected information a total quantity of about 16.25 mld of water is drawn for drinking purposes which works out to about 209.4 mcft per year.

Table 6: Annual water use by industrial and drinking purposes

Sl. No.	Details	Quantity (mcft)	Share to total flow (%)	Share to river flow alone (%)
1	All industries			
(i)	Permitted quantity	290	1.77	4.96
(ii)	Actual drawn	255	1.56	4.36
2	Drinking water in all points	209.4	1.28	3.58
3	Drinking water excluding from reservoir	183.2	1.12	3.13

Existing drawal for industrial use

Most of the industries along the Amaravathy river fall around Solamadevi channel - 7.164 km, Kaniyur channel - 8.045 km and AMC - 19.52 km, though the actual drawal of water is from the river. There have not been significant variations in the number of industries drawing water from the Amaravathy sub basin system. There has been a marginal increase in the total quantum of water used by all the industries over the past decade,. though there have been year to year variations.

Total quantum of water permitted to be drawn by the industries (under agreements) is 290 mcft and the actual quantity drawn by them was about 255 mcft. Actual quantity drawn was close to permitted quantity. Table 6 presents the estimated proportion of water used by industries and domestic sectors. From the tables it is seen that industries use about 5 per cent of the river release or 1.77 per cent of the total basin water as a first approximation estimate. Similarly drinking water use is about 3.58 per cent of river release or 1.28 per cent of basin resources.

Agricultural water use

Quantum of agricultural water use is arrived only as a residual. Records and data to assess water deliveries at different distribution points are absent. As in most other river basins, agriculture is the first and predominant sector to use the water flows n the Amaravathy basin. The Kallapuram and Ramakulam channels and the river channels branching from the earthen anaicuts along the river course were the earliest water delivery structures meant for distributing the water to the agricultural users. With no storage structures along the river or its tributaries, and streams falling into the river, almost the entire water flowed to the tail-end users of the system. With distributed rainfalls across catchments of the river, tributaries and catchments, and all the water received at different points of time flowing into the river, the tail-end ayacut or the old ayacut represented by the river system were getting for agriculture for almost the entire year, compared to lands situated around the head reach. Further, while the catchment is mainly benefited by the southwest monsoon, the old ayacut area is more or less equally benefited by both the monsoons. During these periods, two paddy crops were usually cultivated in the old ayacut in first and second seasons starting from June-July. Sometimes, a third crop was grown in the third season of Feb-March. Besides paddy, irrigated annual crops like sugar cane and banana were also grown. Ground water utilization through wells was a rare phenomenon.

Subsequently, Amaravathy reservoir was constructed, a new ayacut area was created through the contour Amaravathy Main Canal (AMC) and minor reservoirs has been constructed or are being constructed along various tributaries and in falls of the Amaravathy river. In course of time the entire AMC was lined. With these developments, the tail-end regions in the old ayacut season began to suffer. Additionally water diversions for industrial, domestic, commercial uses and also for agricultural in the hitherto unserved areas through unauthorized pumping have started in the middle to tail-end regions. Pollution through industries and bleaching and dying units also started affecting the tail-end users to some extent.

On a broader canvas, thus the balance of water use convenience has overall shifted to the head reach agricultural users – to the new ayacut area compared to the old ayaut and to head reach farmers within each category. The riparian old ayacut region has been forced to go n for a single paddy crop at a late season and the second season is generally substituted with non-water intensive crops like cotton, maize, sorghum etc, with extensive substitution of ground water through wells. Gradually wells have started appearing in the entire basin and supplementing irrigation of crops.

Projections of sectoral use for the future: Methodology

Domestic demand

Domestic water requirement is usually seen as drinking water requirement though in involves a whole lot of other uses. The schemes drawn up for supplying water to domestic needs are also seen as drinking water schemes. In designing and implementing such schemes certain normals are followed. For instance, the existing schemes are designed for supplying 55 litres per person per day in rural domestic dwellings. In urban areas the existing norm is 70 litres per day per person. The total supply is determined taking into consideration these norms and the population the scheme is supposed to serve.

In making future domestic water requirement assessment, the immediate task is to predict the growth in population of areas likely to be served by the Amaravathy basin. It was considered that the population coming under both banks of the river up to a distance of 10 km from the bank is likely to be served by the river. The revenue villages that fall within this zone were identified with the help of census maps. Population data of these villages were collected from the decadal census reports. Annual population growth rates in these villages were estimated using decadal changes in the census data. For instance if P^i_{81} is the population of a village 'i' in 1981, it reaches a level P^i_{91} in 1991 by annual growth process at a rate 'r' to be estimated. The decadal changes are governed by the relationship,

$$P^i_{91} = P^i_{81} (1 + r^i)^{10}$$

From the above relationship, the annual population growth rate is computed as,

$$r^i = \left[(P^i_{91}/P^i_{81})^{1/10}\right] - 1$$

and is used for projecting the population of the village at different points of time in the future.

The population projections could be made for individual villages or for the region supposedly served by the basin. While the farmer is likely to highlight inter-migration among the villages, the later is more likely to highlight overall population growth and migration across the region. The former is more relevant for micro-level water distribution planning and investments, while the later might to be a more relevant indicator of actual water requirements of the region.

With projections of population to be served by the basin water, the actual requirement is worked out in a straight forward manner. The requirements are calculated, assuming that the population is to be served at existing norms of 55 litres/person/day in rural areas and 70 litres/person/day in urban areas. Thus the requirement for any time period in mcft would be,

$$R_t = [(P^r_t \times 55) + (P^u_t \times 70)] \times 365 \times 0.03531/10^6$$

Where R_t is the water requirement in year t in mcft, P^r_t is the projected population in rural areas and P^u_t in urban areas in year t.

Norms for estimating future requirements vary depending on the yardsticks one adopts to represent the acceptable standard of living. Per capita per day water requirement recommendations made by several organisations vary from 100 to 15 litres. Compared to these recommendations, existing supply norms in the Amaravathy basin is on the lower side. Hence, allowances may have to be made for higher per capita need in future water requirement estimation, though not at the highest standards prescribed. As an intermediary option, water requirements at different future points of time in the river basin are estimated assuming a per capita

requirement of 100 litres both for rural and urban regions.

Industrial demand

Existing industrial water withdrawal was estimated based on actual water drawn by the licensed industries. They are usually permitted to draw a fixed quantity of water from the river. This represents the maximum quantity that they can draw. Actual withdrawals varied among industries and over a period of time. The licenses to draw water are granted over specific time periods and the industries are expected to renew their licenses periodically if they continue their operation and require river water.

In making future projections of industrial water requirement as a first approximation it is assumed that the existing industries will continue their operations and their drawls would grow according to past trends. Though there have been year to year variations in the drawls by industries, the industries are assumed to have followed a pattern of compound growth trend in the past, commensurate with their business activities. In general, the past drawls by each industry (I_t^i) is assumed to have followed the growth path,

$$I_t^i = I_0^t (I + r)^t$$

where I_t^i is the water drawn by the i^{th} industry in year t, which has followed a growth rate of 'r' from an initial drawal of I_0^i in year 1991-92. The estimation proceeds via regression estimation of log transformed version of the above expression,

$$\ln I_t^i = \ln I_0^t + t \ln (I + r)$$

This is expressed as,

$$i_t^i = i_o^i + \alpha t$$

where $i_t^i = \ln I_t^i$, $i_0^i = \ln I_0^t$ and $= \ln (I + r)$

The last expression is a standard regression from which a can be estimated, and the growth rate r recovered as exp $\alpha - 1$.

The growth rate in water drawal calculated as above for each industry over all industries at any future point gives the total industrial water requirement at that point. Additionally the projections were also made assuming that the number of industrial units drawing water from the basin would also increase by 5 per cent besides the existing growth in demand of the individual units.

Commercial demand

Unlike domestic and industrial sectors, not even partial recorded information is available of the commercial sector, which could form the basis for future projections. Hence, the estimated had to totally rely on field sample surveys and estimates based on them. Since the commercial sector is almost exclusively served by the transporters, estimates were made regarding the number of pumpsets and quantum of water supplied. Enquiries revealed that 100 pumpsets supplying on an average 3 tanker loads of 12000 litres/day each for a duration of about 120 days (4 months a year) would be a reasonable estimate. Additionally, the commercial use of water resources was assumed to grow at annual compound rates of 5 and 10 per cent points to reflect increasing economic activities in the basin.

Table 7: Domestic water requirement projections under existing norms (in mcft) (Requirement at 55 and 70 1/person/day for rural and urban areas respectively)

Projection details	2001	2010	2020	2025
Rural				
(i) Total (Overall projections)	522.16	549.52	581.59	598.33
(ii) (based on individual villages)	541.43	608.34	726.41	813.89
Difference (ii-i)	19.27	58.82	144.82	215.57
Difference (%)	3.69	10.70	24.90	36.03
Urban				
(i) Total (Overall projections)	339.67	350.36	362.63	368.92
(ii) (based on individual villages)	360.19	413.56	512.96	585.05
Difference (ii-i)	20.52	63.21	150.33	216.12
Difference (%)	6.04	18.04	41.46	58.58

Projection exercise

Projections for various sectors using water in the Amaravathy basin were done for a period of 25 years up to 2025, with break up details for the years 2001, 2010, 2020 and 2025. The projection for the year 2001 serves as a benchmark for contrasting the projections with the estimated existing sectoral distribution. Domestic requirement projections were based on population projections as discussed earlier. Summary results are presented in the following Tables 7-14.

Total domestic water requirements based on existing supply norms of 55 litres/person/day projected as per growth in total population of the supply range of the banks (10 km on each side) varied from about 522 mcft

in 2001 to about 600 mcft in 2025 in rural areas. Similarly in urban areas with the norm of 70 litres/person/day, the projections varied from about 340 mcft to about 368 mcft. The projected total demand thus ranges from 862 mcft in 2001 to about 967 mcft in 2025.

Table 8: Domestic water requirement projections under desired norms (in mcft) (Requirement at 100 1/person/day for both rural and urban areas respectively)

Projection details	2001	2010	2020	2025
Rural				
(i) Total (Overall projections)	949.39	999.12	1057.44	1087.87
(ii) (based on individual villages)	984.42	1106.06	1320.75	1479.80
Difference (ii-i)	35.03	106.94	263.31	391.94
Difference (%)	3.69	10.70	24.90	36.03
Urban				
(i) Total (Overall projections)	485.24	500.51	518.04	527.03
(ii) (based on individual villages)	514.55	590.81	732.80	835.78
Difference (ii-i)	29.32	90.30	214.76	308.75
Difference (%)	6.04	18.04	41.46	58.58

Table 9: Industrial water requirement projections under existing growth (in mcft)

Projection details	2001	2010	2020	2025
(i) Total (Overall projections)	269.82	358.84	477.23	550.35
(ii) (based on individual industries)	178.69	260.49	515.23	795.07
Difference (i-ii)	91.13	98.35	–38.00	–244.72
Difference (%)	33.77	27.41	–7.96	–44.47

Table 10: Industrial water requirement with 5% growth in units under existing growth (in mcft)

Projection details	2001	2010	2020	2025
(i) Total (Overall projections)	283.31	376.78	501.09	577.87
(ii) (based on individual industries)	187.62	273.52	540.99	834.83
Difference (i-ii)	95.69	103.26	–39.90	–256.96
Difference (%)	51.00	37.75	–7.38	–30.78

Domestic demand (Tables 7 and 8) in terms of share ranged from 5.25 per cent in 2001 to about 5.89 per cent in 2025. However, when population growth rates are considered village wise, and projections are made individually and summed up, the projections are more than 58 per cent higher than the projections based on total population. The projections in this case range from about 901 mcft in 2001 to about 1398 mcft in 2025. These might reflect the differences in base population and the differential migration rates as discussed earlier.

Table 11. Commercial water requirement under 5 and 10 per cent growth rates (in mcft)

Projection details	2001	2010	2020	2025
Commercial (5% growth)	15.25	23.66	38.55	49.20
Commercial (10% growth)	15.25	35.97	93.29	150.25

Projections based on overall population growth are statistically more reliable. The requirement projections on this basis for 2001 at about 862 mcft is four times higher than the existing estimated distribution of 209 mcft through various tapping points. This is equivalent to either supplying the entire population along a 2.5 km stretch on both sides of the river (assuming even distribution of rural and urban range) or serving 25 per cent of the population along a 10 km range as assumed in the projections. Field enquiries support the later assumption to be more plausible. It would perhaps be necessary to enhance the coverage of population percentage for water supplies over a period of time. If the objective of achieving cent by cent coverage by 2025 could be achieved, the total water requirement under the existing norms would be 967 mcft, representing about 5.89 per cent of the total water resources of the Amaravathy basin.

Additionally, if the improving standards of living also demand enhancing per capita water supply to at least 1001/day, the total demand for domestic purposes would increase from 1434 mcft in 2001 to about 1615 mcft in 2025 on a 100 per cent coverage basis. The share percentage to total basin resources would increase from 8.74 in 2001 to 9.84 in 2025 correspondingly. This might perhaps be an estimate on the higher side and might not be realized with the existing resource and infrastructural constraints.

Considering industrial water share, (Tables 9 to 10) the existing level as estimated based on actual quantities drawn by the licensed industries is about 255 mcft, representing about 1.56 percentage of the total basin resources. The maximum permitted or licensed quantity is about 290 mcft representing 1.77 per cent of the basin resources. The projections based on existing growth pattern increase from 269 mcft in 2001 to 550 mcft in 2025, representing a share growth from 1.64 per cent to 3.35 per cent in the corresponding period (the constant

Table 12: Projected non-agricultural water needs under normal growth scenario

Sectors	Quantity in mcft				Per cent share			
	2001	2010	2020	2025	2001	2010	2020	2025
Domestic-Rural	522.16	549.52	581.59	598.33	3.18	3.35	3.54	3.65
Domestic-Urban	339.67	350.36	362.63	368.92	2.07	2.14	2.21	2.25
Domestic-Total	861.83	899.87	944.22	967.25	5.25	5.48	5.75	5.89
Industry	269.82	358.84	477.23	550.35	1.64	2.19	2.91	3.35
Commercial	15.25	23.66	38.55	49.2	0.09	0.14	0.23	0.30
Total-Non agri	1146.90	1282.37	1459.99	1566.79	6.99	7.82	8.90	9.55

Table 13: Projected non-agricultural water needs under normal growth scenario

Sectors	Quantity in mcft				Per cent share			
	2001	2010	2020	2025	2001	2010	2020	2025
Domestic-Rural	949.39	999.12	1057.44	1087.87	5.79	6.09	6.44	6.63
Domestic-Urban	485.24	500.51	518.04	527.03	2.96	3.05	3.16	3.21
Domestic-Total	1434.63	1499.63	1575.48	1614.90	8.74	9.14	9.60	9.84
Industry	283.31	376.78	501.09	577.87	1.73	2.30	3.05	3.52
Commercial	15.25	35.97	93.29	150.25	0.09	0.22	0.57	0.92
Total-Non agri	1733.19	1912.38	2169.86	2343.01	10.56	11.65	13.22	14.28

overall average availability of 16408 mcft in the basin through flows).

It might be seen that the predicted requirement of 269 mcft for 2001 representing 1.64 per cent share of the basin resources is very much closer to the estimate of existing drawal of 255 mcft representing 1.56 per cent. The industrial requirements are thus expected to double from 1.64 to 3.35 per cent in a 25 year period from 2001 at the existing level of water use. The number of industrial units themselves may increase, besides growth in water consumption by individual units over time due to economic development. To make allowance for the industrial growth, additional projections assuming 5 per cent growth in an existing number of industries were made. In this scenario, the water requirements of the industries increases from 1.73 per cent in 2001 to 3.52 per cent in 2025. The growth is only modest reflecting the reality assessment and perspectives of the industrial water users.

Unlike domestic and industrial sectors, not even partial past recorded information is available for the commercial sector, which could form the basis for future projections. Hence, the estimates have to totally rely on field sample surveys and estimates based on them. Since the commercial sector is almost exclusively served by the transporters, estimates were made regarding the number of pumpsets and quantum of water supplied. Enquiries revealed that 100 pumpsets supplying on an average 3 tanker loads of 12000 litres/day each for a duration of about 120 days a year, would be reasonable estimates. Additionally, the commercial use of water resources were assumed to grow at annual compound rates of 5 and 10 per cent points to reflect increasing economic activities in the basin (Table 11).

With a modest 5 per cent growth assumption, the estimated share of commercial sector in the basin resource increased from 15.25 mcft in 2001 to 49.20 mcft in 2025. In percentage share, this reflects an increase from a meagre 0.09 to 0.30 per cent. On the assumption of 10 per cent growth rate, the use increases from 15.25 mcft in 2001 to 150.25 mcft in 2025, representing a jump from 0.09 per cent to nearly one per cent (0.92) of the basin resources.

Though in share terms, the commercial sector represents only a small percentage, it has greater significance if one considers the fact that a part of this share goes to highly polluting uses like dying and bleaching.Thus though industrial and commercial sectors are relatively low water shares of the Amaravathy basin, they are significant players in terms of polluting even the basin. Thereby they affect a much larger proportion of the basin resources than they actually share themselves.

Turning to overall water share, (Table 12 and 13) among different non-agricultural sectors, the existing estimates reveal that the share is relatively small, with domestic and industrial uses accounting for only about 2.85 per cent of the Amaravathy basin resources. Commercial sector as of now accounts for only an insignificant share of about 0.01 per cent.

In the first scenario of projections, (Table 12) domestic sector requirements are assumed to be based on the existing water supply norms of 55 litres of water per person per day in rural areas and 70 litres/day/person in urban areas. Water is expected to be required by residents of villages on both sides of the river bank up to a distance of 10 km. The industrial users are assumed to continue their existing operations and their water requirements grow accordingly. Commercial sector needs are expected to grow at 5 per cent of the existing estimated share rates. With these basic assumptions, the total non-agricultural requirements of basin water are expected to grow from 1147 mcft in 2001 to 1567 mcft in 2025 representing a rise in total share from 6.99 per cent to 9.55 per cent. This is the normal baseline scenario representing the bottom line of water requirement by the non-agricultural sector in the basin.

The alternative scenario of projections (Table 13) assume 100 litres of water requirement per person per day for the domestic sector supposed to be served by the basin, 5 per cent growth rates in the number of industries in addition to the existing growth in water needs of individual industries, and 10 per cent growth in water requirements by the commercial sector. Under these high end water requirement scenario by the non-agricultural sector, their total water requirement is likely to grow from 1733 mcft in 2001 to about 2343 mcft in 2025 representing a share growth from 10.56 per cent to 14.28 per cent. Compared to the national and global estimates of the non-agricultural sector water share of about 15 per cent, in Amaravathy basin, it is less at 9.5 per cent in the normal scenario even in 2025 at the existing and projected user rates. Only under the high growth assumption does the non-agricultural sector requirement grow to about 15 per cent of the basin resources in 2025, making no special case for emerging management measures in the Amaravathy basin. As mentioned earlier, perhaps issues like pollution are more relevant in the basin than intersectoral water allocation per se.

Though the estimates and likely growth in the non-agricultural sector water requirements in the basin are within overall tolerable bounds even in 2025, the issue to be kept in mind is that these requirements have to be met mostly from the water let in the river system. If the release and appropriation are not evenly distributed, the old ayacut area represented by the river delivery system will suffer compared to the new ayacut area represented by the AMC delivery system.

Decadal flows in the reservoir account for about 16408 mcft of which an average of 5986 mcft (36.5%) is lost to the river through surplus weirs and sluice leakage. The river release accounts for about 6254 mcft (38%) and AMC release about 3797 mcft (23.14%). The riparian dam level canals (Kallapuram and Ramakulam) account for 1141 mcft (6.95%) with about 319 mcft (1.95%) lost through evaporation.

While most of the non-agricultural sector requirements are met from the river delivery system, one advantage here is the buffer represented by the release of excess water through surplus weirs to the extent of 36.5 per cent of the basin resources. This is mainly on account of the smaller storage capacity of the reservoir. Given the quantum of resources in the basin, the likely requirements of water by the non-agricultural sector could be met without undue effect on the agricultural sector. To this end adequate steps are to be taken to use water effectively in the agricultural sector, besides taking steps to prevent the pollution of water by the industrial and commercial sectors.

Agricultural water requirement

Table 14 presents the total agricultural water requirements for the different crops grown in the basin based on their required water rates as recommended. It is seen that the agricultural crops require about 10,000 mcft of water if the entire crop irrigation is to be under canal irrigation in the ayacut area, out of the total flow of about 16400 mcft in the basin, besides the non-agricultural sector requirements of about 1150 mcft at the existing levels of water utilization (Table 13).

Table 14: Estimated water requirement for average area cultivated under crops in Amaravathy basin

Crop	Actual area (in ha)	Water requirement (Ha Cm)	Total water needed in mcft
Paddy	9725.283	110	3777.397
Sugarcane	5274.964	250	4656.474
Coconut	2076.445	160	1173.109
Groundnut	461.9433	50	81.55609
Banana	82.99595	250	73.26468
Others	2384.304	40	336.759
Total	20005.94	–	10098.56

Water use in the basin and distribution efficiency

Thus total water requirements of all sectors in the basin put together require about 11150 mcft which appears to be manageable within the total basin resources of 16400 mcft at about 68 per cent water use efficiency. However, the above estimate takes into consideration only a single crop of paddy wherever it is cultivated. Other than the annual crops, in the old ayacut area double paddy crops are grown under canal water in some pockets. If it is assumed that about 50 per cent area under paddy under old ayacut is under double paddy crop, there would be an additional paddy crop area of about 3000 hectares within an additional water demand of about 1165 mcft, making the total water requirement to be about 12315 mcft. Consequently, the entire system has to operate with an overall efficiency of about 75 per cent, which itself is at a higher order compared to the normal efficiency levels of canal irrigation systems in the state estimates that vary widely from 34 to 60 per cent.

Additional dimensions complicate matching supply with requirements in the basin. Water receipts through rainfall are not temporally uniformly distributed. Storage capacity of the reservoir being limited, water received during peak rainfall periods in the catchments can not be adequately stored and used. While AMC is lined and modernized, the long stretch of the river delivery system is traditional with associated losses through seepage and evaporation. The river course being long with intermittent stretches unserved by formal channels, unauthorized withdrawals by way side farmers is common. This is aided by free availability of electricity and absence of strict enforcements. As indicated earlier about 10,000 acres or roughly about 4000 hectares of land is irrigated by these withdrawals. Assuming an average water requirement of 100 hectare centimetre per hectare of crops grown in these areas, the additional burden on the system works out to about 1425 mcft, accounting for about 8.5 per cent of the water resources.

Existing requirements and supply management itself is under stress as discussed. In future as demands from non-agricultural sectors are likely to grow as projected, the stress on the system will be more pronounced. Management thus becomes critical on both supply and demand sides. On the supply side, improving the storage capacity of the reservoir, avoiding delivery losses along the river delivery system and management of the unauthorized withdrawals could help. On the demand side the largest gains have to come from rationalizing water use in the agricultural sector. This might involve reorganizing the cropping pattern, substituting high water intensive crops with economically comparable less water intensive crops of lesser duration. For instance, paddy to an extent may be substituted by crops like cotton and groundnut. Groundwater utilization in the basin, supplementing the canal water needs to be rationalized by taking into consideration the potential and actual recharge in the basin region. Water use efficiency of all the crops cultivated in the entire Amaravathy basin command area need to be improved over the years to match the growing demand pressure.

Options for future basin resource management

- On the supply side, improving storage capacity of the reservoir, avoiding delivery losses along the river delivery system and management of the unauthorized withdrawals could help.
- On the demand side the biggest gains have to come from rationalising water use in the agricultural sector. This might involve reorganizing the cropping pattern, substituting high water intensive crops with economically comparable less water intensive crops of lesser duration. For instance paddy may be substituted by crops like cotton and groundnut.
- Pollution, though not presently critical, is an emerging issues due to the operation of a large number of small scale-dyeing and bleaching units. Corrective measures need to be initiated in the Amaravathy basin before the problem turns worse. Quality loss would have a multiplier effect on water resource availability.
- On the organisational side, the government has to effectively delegate powers of appropriation and management to local representative bodies.
- The WRO or a similar agency should be made the effective coordinating body and all the local stakeholders including local bodies, TWAD Board and other water users, must be made accountable to the quantum of water used by them to that agency. The agency must in turn strengthen its house keeping operations in terms of maintaining adequate field staff to effectively manage water distribution, properly recording flows at various delivery points and the actual quantum used by different sectors.
- All water using sectors shall be made accountable for the maintenance of the system through payment of user charges to the designated agency.
- Dispute settlement mechanism should be strengthened and long delays eliminated. Arbitration committees could be appointed and the issues resolved at the earliest.

Clarity of future course of action would perhaps be necessary in the context of increasing advocacy to

move towards market economy. Agency sponsored reform measures do not appear to have official continuity nor do they appear feasible in the present situation in which a major section of the population is unable to pay for the domestic water uses. Ad hoc reform measures may only have destabilisation effect on the existing system without substituting it with an alternative effective system.

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If you think you're too small to make a difference, you've obviously never been in bed with a mosquito.

– Michelle Walker

Feature

Contract Farming System for Snow-Peas Cultivation in Punjab

Manjeet Kaur, Ranjeet Singh & M.K. Sekhon

This study is confined to snow-peas cultivation through contract farming in Sunam block of Patiala district, Punjab. Fifteen farmers operating in 43 acres (86%) of contract area were selected randomly and interviewed to assess the economics of cultivation of snow-peas over its competing crops viz, wheat and local peas. Lack of availability of labour at time of picking, frequent attack of fungus, high cost of production were some of the production problems faced by sample farmers. But on the whole contract farmers were satisfied with the profitable venture and were interested to bring more area under such crops, providing that price and marketing of produce is assured.

Manjeet Kaur, Ranjeet Singh and M.K. Sekhon are with Department of Economics, PAU, Ludhiana.

The monoculture of wheat and rice has created many environmental problems in Punjab. Presently the main concern of planners and policymakers is how to replace rice-wheat cultivation with some other crops. This can happen only if other alternative enterprises are at least as remunerative as the rice-wheat system. The Johl Committee Report (2002) on 'Diversification of Punjab Agriculture' recommended that one million hectares, each of wheat and paddy, be brought under high value crops. Thus the diversification to more productive and remunerative crops is the new milestone to be achieved in Punjab agriculture. The cultivation of fruits and vegetables offers a plausible alternative. This cultivation is not only employment intensive, but also enhances the gross as well as net returns of the farmers. However, due to perishability and seasonality of these crops, the farmers are not able to sell their produce as profitably. There are frequent gluts in the markets, resulting in low prices and losses to the farmers. In such a situation a system of contract farming in which the producer gets assured market and assured price and buyers get quality produce at specified rates, may help in a better way. Moreover, the contract farming system forms the most heartening part of the vision of National Policy on Agriculture (NPA).

In Punjab contract farming made an entry in the early 1990s with Pepsi Foods into tomato and chillies and Nijjer Agro Foods Ltd. There have been some local initiatives involving small-scale units especially in horticulture produce. In this paper an attempt has been made to evaluate the functioning of one such unit namely 'Patiala Horticulture Limited' engaged in contract farming in 'snow-peas' cultivation, an export-oriented vegetable (with no local demand). The crop is successfully grown in 50 acres in Sunam block of Patiala district.

Background of the contacting firm and its mode of operation

Patiala Horticulture Private Limited located in

Sunam district of Patiala is a registered firm and has been in operation since 2001. It is engaged in cultivation of 'snow-peas', a vegetable which can be grown successfully in Punjab conditions This particular vegetable is exported to Australia (Perth, Sydney and Melbourne) and England (London) and has no local demand. The firm has refrigerated transport and sophisticated cold storage facility to handle 50 acres of produce. The firm has selected the contract farmers based on the locality of the farm and the farmers' willingness to cultivate the crop/to take risk. The firm supplies imported seed, ropes and sticks (required to support the plants), extension services, package of practice to the snow-peas growers free of cost.

The firm has fixed the contract price of Rs. 25/kg during 2002-03 keeping in view the minimum net returns of at least Rs. 15,000 per acre, by working out the cost of cultivation of snow peas/acre and the average yield of the crop. The firm provides sophisticated transportation facilities at the farm level to the growers free of cost. The produce is brought at the factory site and after grading, high quality produce is exported. The payment to the farmers is made in cash within fifteen days of procurement.

Socio-economic profile of selected contract farmers

To study the economics of cultivation of snow-peas with respect to the competing crops and to examine farmers' response towards contract farming, 15 farmers operating 43 acres (86%) of contract area were selected randomly and interviewed during the rabi season of 2002-03. The information was recorded on specially designed schedules for the purpose.

The selected farmers are divided into following three categories depending upon their size of operational holding:

Category size of operational holding*

I. ≤ 10 acres (semi medium)

II > 10 and ≤15 acres (medium)

II > 15 acres. (large)

* none of the contract farmer belongs to small farm size category (< 5 acres of land)

Socio-economic profile of the selected contract farmers has been given in Table 1. It is clear from the table that more than 50 per cent (53.33%) farmers were between the age group of 26 to 50 years. From the selected farmers 13.33 per cent were educated up to primary level, 40 per cent up to middle level and 46.67 per cent were educated above middle level. the highest proportion of farmers (66.67%) with education above middle level belong to category I, and the highest percentage of farmers educated up to middle level belong to category II (71.42%). Average size of operational holding of these sampled farmers were 9.67, 13.07, 19.6 and 14.57 acres for category I, II, III and overall respectively. It was 100 per cent irrigated and the source of irrigation was both electric motor and canal for all the categories of farmers. Average area under snow-peas crop was 1, 5, 3, 21, 3.20 and 2.87 acres on category I, II, III and overall respectively. the range of area under contract varied from half an acre to 5 acres on sampled farmers.

Table 1: Socio-economic parameters of snow-peas cultivators

	Particulars	Category			
		I (n=3)	II (n=7)	III (n=5)	Overall (n=15)
1.	**Age**				
	Up to 25	–	1 (14.29)	1 (20.00)	2 (13.33)
	26–50	2 (66,67)	4 (57.14)	2 (40.00)	5 (33.33)
	>50	1 (33.33)	2 (28.57)	2 (40.00)	5 (33.33)
2.	**Education of farmer**				
	Primary	1 (33.33)	1 (14.29)	–	2 (13.33)
	Middle	–	5 (71.42)	1 (20.00)	6 (40.00)
	Above middle	2 (66.67)	1 (14.29)	4 (80.00)	7 (46.67)
3.	Average Family Size	7	9	7	8
4.	Average No. of children	1	2	3	2
5.	Avge. No. of working members	3	4	4	4
6.	Avge. Size of operational holding (acres)	9.67	13.07	19.6	14.57
7.	%age irrigated area	100.00	100.00	100.00	100.00
8.	%age farmers having electric motor for irrigation	100.00	100.00	100.00	100.00
9.	%age farmers having canal irrigation	67.00	85.71	100.00	66.5
10.	Area under contract crop	1.5 (4.5)	3.21 (22.5)	3.2 (16.00)	2.87 (43.00)

Economics of Snow-Peas Cultivation

Vegetable cultivation provides higher returns per

Table 2: Comparative analysis of costs and returns from the production of snow-peas and competing crops among different categories of contract growers

Item/Category	Snow peas				Wheat				Local peas			
	I	II	III	Overall	I	II	III	Overall	I	II	III	Overall
Land preparation	1000.0 (5.5)	941.4 (5.1)	880.0 (4.3)	932.7 (4.9)	900.0 (19.6)	816.7 (18.6)	725.0 (14.9)	802.8 (17.5)	900.0 (9.3)	812.5 (8.3)	783.3 (8.1)	820.3 (8.3)
Seed	0.0	0.0	0.0	0.0	320.0 (7.0)	366.7 (8.3)	380.0 (7.8)	361.8 (7.9)	2225.0 (22.9)	2087.5 (21.4)	2266.7 (23.3)	2174.7 (22.4)
Fertilizer	1225.0 (6.8)	1270.7 (6.8)	1359.0 (6.6)	1291.0 (6.8)	980.0 (21.4)	1013.3 (23.0)	1018.0 (20.9)	1008.2 (21.9)	982.3 (10.1)	1101.3 (11.3)	977.3 (10.0)	1036.2 (10.7)
Plant protection	86.7 (0.5)	114.3 (0.6)	57.0 (0.3)	89.7 (0.5)	810.0 (17.6)	458.3 (10.4)	470.0 (9.6)	532.5 (11.6)	375.0 (3.9)	479.8 (4.9)	462.7 (4.8)	453.1 (4.7)
Hoeing	1530.0 (8.4)	1635.7 (8.8)	1338.0 (6.5)	1501.2 (7.9)	180.0 (3.9)	109.6 (2.5)	225.0 (4.6)	162.2 (3.5)	865.2 (8.9)	795.6 (8.2)	816.7 (8.4)	816.5 (8.4)
Irrigation charges	274.4 (1.5)	220.2 (1.20)	205.3 (1.0)	220.7 (1.2)	160.0 (3.5)	170.0 (3.9)	160.0 (3.3)	164.7 (3.6)	255.0 (2.6)	250.0 (2.6)	243.3 (2.5)	248.8 (2.6)
Harvesting/ picking	14000.0 (77.3)	14400.0 (77.5)	1668.0 (81.3)	15027.0 (78.7)	1100 (24.0)	1300 (29.6)	1755 (36.0)	1412.0 (30.7)	3233.2 (33.3)	3411.2 (35.0)	3356.5 (34.5)	3357.4 (34.5)
Marketing	0.0	0.0	0.0	0.0	140.0 (3.0)	164.3 (3.7)	140.0 (2.9)	151.4 (3.3)	865.2 (8.9)	795.6 (8.2)	816.6 (8.4)	816.5 (8.4)
Total variables	18116.1 (100.0)	18582.3 (100.0)	20519.3 (100.0)	19062.3 (100.0)	4590.0 (100.0)	4398.9 (100.0)	4873.0 (100.0)	4595.6 (100.0)	9700.9 (100.0)	9733.5 (100.0)	9723.1 (100.0)	9723.5 (100.0)

Table 3: Returns over paid out cost of snow-peas and competing crops

Particulars	Gross returns	Costs	Returns over cash costs
Snow-Peas			
Category I	36250.0	18116.1	18133.9
Category II	36607.1	18582.3	18024.8
Category III	38250	20519.3	17730.7
Overall	37083.3	19062.3	18021.0
Wheat			
Category I	11160.0	4590.0	6570
Category II	11780.0	4398.9	7381.1
Category III	12090.0	4873.0	7217.0
Overall	11759.3	4595.6	7163.7
Local Peas			
Category I	24300 (13.31)	9700.9	14599.1
Category II	23400 (14.58)	9733.5	13666.5
Category III	25200 (13.32)	9723.1	15476.9
Overall	24180 (13.88)	9723.5	14456.5

Figures in parentheses indicate percentage of picking cost to gross returns.

unit area in less time than cereal production. Being labour intensive it also offers more employment opportunity not only to the family labour but also to hired labour (Singh 1999; Sharma et. al 2000; Kaur and Kaur 2004). This section deals with the economics of snow-peas cultivation along with its competing/replaced crop for different farm size group of contract farmers, to examine the profitability of snow-peas cultivation over its competing crops. The total paid our cost (cash costs) of snow-peas vis-à-vis its competing crops has been worked out and presented in Table 2. Net gain/loss of snow-peas cultivation in comparison to its competing crops has been incorporated in Table 3. The cost of cultivation of snow-peas varied from between Rs. 18116.10 to Rs. 20519.30 in different farm situations; it worked out to be Rs. 19062.23 on an average farm situation. The break up of the cost of cultivation showed that the picking of snow-peas (done manually) is the major item of cost, which constituted 78.7 per cent of the total cost on an average farm situation. Among different farm size groups the cost of cultivation of snow-peas was lowest among semi-medium farm size (I) and increased with the increase in the size of farm. A similar trend was observed in the share of labour in total cost, which might be due to higher use of family labour on semi-medium farms, contrary to medium and large farm situations.

There is no marketing cost for farmers involved in snow-peas cultivation, because the produce is procured at the farm gate and transported to the company site by the company personnel in specialized refrigerated vans of the company. The cost of cultivation of wheat and local peas worked out to Rs. 4595 and 9723.5 respectively on

an average farm situation. The cost of cultivation of wheat was lowest on a medium farm size, followed by semi medium and large, whereas for local peas it is lowest on a semi-medium farm size followed by large and medium farm size group. It indicates that the cultivation of snow-peas is capital intensive and required more funds as compared to wheat and local peas cultivation. The returns over variable costs for snow-peas varied between Rs. 17730.7 and Rs. 18133.9, whereas it ranged between Rs. 6570 to 7381.1 for wheat and Rs. 13665.5 to Rs. 15476.9 for local peas different farm size categories (Table 3). Thus snow peas compete favourably with local peas and wheat. Besides its profitability, its cultivation also offers more employment opportunities to labour. The earning of labour only for picking of snow-peas was about 40 per cent of the gross income of the farmers on an average farm situation. In local peas cultivation, share of labour was around 14 per cent of the gross income of farmers. Thus snow-peas cultivation provides higher income to local labour also.

Problems faced by the snow-peas growers/ company personnel

Though the cultivation of snow-peas was profitable for the sample farmers, even then they reported some production and marketing problems faced in this system. The production problems faced by sample farmers were lack of availability of labour, especially at the time of picking; frequent attack of fungus; high cost of production etc. Marketing problems perceived by the farmers included deduction on the basis of quality and delayed payment; overall they were interested to adopt alternative crops as the wheat-paddy cultivation has become less profitable. On an average 30 per cent of wastage at the cost of poor quality was borne by the producers during the period of study.

The sample farmers also gave a few suggestions on how to make the system more successful, including:

- The quality/standard of the produce should be pre-decided so that the cost incurred on picking of sub-standard produce could be saved.
- The Govt. should support the contractor/agency involved in contract farming.
- Size of operation (50 acres) is small; it should be on a larger scale.

Conclusions and Policy Implications

In conclusion, snow-peas has a comparative advantage/competitive edge, through contact farming. Besides giving high returns to the farmers the earnings of local labour also increased. About 40 per cent of the gross returns were distributed among local labour only for picking of the crop.

Major problems faced by the farmers were lack of availability of labour followed by deduction on the basis of quality of the produce. Otherwise all the farmers were satisfied with the function/dealing of company personnel and were willing to bring more area under such crops, where assured prices are there. High airfreight charges, risky payments and procedural formalities in importing seed were the problems faced by company personnel. Keeping in mind the interests of producer and company, it is suggested that such private initiatives should be supported/encouraged by the Government to reduce the problem of wheat-paddy monoculture in the State and improve the income/earnings of farmers as well as local labour.

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Success is simple. Do what's right, the right way, at the right time.

– Arnold H. Glasgow

Feature

Crop-biotechnology and Agricultural Development in India

K.N. Selvaraj

Research and development in biotechnology is now recognized to be an essential and increasingly important element of a critical strategy integrating both conventional and biotechnology applications in order to achieve future food security. There has been a significant growth in the global area in which commercial transgenic crops have been planted. India is expected to emerge as a strong player in the consumption market of biotech products in the coming years. Ultimately, the success of agrobiotechnology depends on the realization of tangible economic and environmental benefits by agriculturists.

K.N. Selvaraj is associate professor at Tamil Nadu Agricultural University, Coimbatore.

Growth in India's demand for foodgrains and processed products is expected to increase as a result of growth in population and income per capita. Population in the country is projected to grow to 1348 million by 2025 with a requirement of 360 million tonnes of foodgrains (Pental, 1998). On the demand side, meeting the food needs of a growing population and overcoming nutritional deficiencies are prime considerations. On the supply side, lack of infrastructure and inconsistent supplies of modern inputs like fertilizers, seeds, and mechanical implements limit the productive capacity of agriculture.

Limits on productive capacity are also placed through both biotic and abiotic stresses. The land frontier has already been closed for agriculture and there are other competing demands from outside agriculture. The additional food will have to be produced on existing agricultural land or marginal soils. It is now widely recognized that conventional technology alone will not allow food, feed and fibre production to increase sufficiently to meet the needs of the growing population.

No doubt agricultural production in India has increased many times due to a technological breakthrough in agriculture. There is now high yielding input responsive varieties with multiple resistances to insects and diseases, better quality seeds, and shorter growth duration, the achievement in incorporating tolerance to abiotic stresses such as drought and salinity etc. However, in recent years, agricultural productivity has come to near stagnation and the marginal growth rates in productivity of crops have not shown further improvement due to technological stagnation. Now, the issue is how to provide low cost crops with multiple traits so that comparative advantage in agricultural production is maintained and the livelihood security of most of the agricultural population is sustained. There is also a growing demand for eco-friendly crops and resource management technologies due to

environment-related problems created by the green revolution technologies.

Why Biotechnology?

There was an impressive growth in production of agricultural commodities due to resilience of agricultural technology, which brought out a substantial increase in productivity of crops. The compound growth rates (Table 1) indicated that both production and productivity of almost all the crops exhibited a significant growth over the years. The growth is mainly due to a development of high yielding varieties with suitable traits, planned investment made in agriculture through expansion of irrigation facilities and spread of fertilizers and credit outlets, coupled with favourable/remunerative product prices.

The demand for food articles depends on the growth of population, income per-capita, distribution of income, elasticity of demand for food (price and income) and other requirements. It is argued that among the twin forces that determine the rate of growth of demand for food, an increase in the growth rate of population leads to a direct increase in the growth rate of total demand for food and growth in per capita income increases rate of growth of demand for foodgrains albeit at a lower rate. In the process of development (Srinivasan, 1987) it is increasing per capita income that is the dynamic factor underlying the growth in food demand (Mellor, 1983).

Table 1: Production of Foodgrains in India

(Million tonnes)

Year	Rice	Wheat	Coarse cereals	Total cereals	Total pulses	Total food grains
1990-91	74.29	55.14	32.70	162.13	14.26	176.39
1991-92	74.68	55.69	25.99	156.36	12.02	168.38
1992-93	72.86	57.21	36.59	166.66	12.82	179.48
1993-94	80.30	59.84	30.82	170.96	13.30	184.26
1994-95	81.81	65.77	29.88	177.46	14.04	191.50
1995-96	79.98	62.10	29.03	171.86	12.31	180.42
1996-97	81.74	69.35	34.10	168.11	14.25	199.44
1997-98	82.53	66.35	30.40	179.28	12.98	192.26
1998-99	85.99	70.78	31.46	188.23	14.81	203.04
1999-00*	88.55	70.10	29.36	188.01	13.55	201.56
CGR **	1.97	3.05	-0.17	1.78	0.69	1.85

* - As on 27.3.2000

** - Estimated compound growth rate (per cent)

Source: Agricultural Statistics at a Glance (2000)

It is observed from the demand estimates that for the country to be self sufficient in foodgrain production, the growth rate of domestic output should henceforth accelerate to 3.5 to 4 per cent per annum from the level of 2.7 per cent per annum achieved during the last 40 years from 1949-50 to 1989-90 (Bhalla, 1995). Given the situation India has to produce a minimum of 230 to 240 million tonnes by 2001. The annual growth in foodgrain production was 2.67 per cent (1967-68 to 1995-96), 2.86 per cent (1980-81 to 1995-96) and 1.70 per cent (1990-91 to 1996-97) (Economic Survey, 2000). These figures reveal that the incremental output per year must be more than what the country realized today (Table 2).

Table 2: Indian Foodgrain Requirements

(Million tonnes)

Commodities	2010
Rice	107.29
Wheat	79.57
Other cereals	34.89
Total cereals	221.75
Pulses	28.46
Total foodgrains	250.21
Milk equivalent	107.21

Source: Radhakrishna and Ravi (1990)

Table 3: Demand-supply Gap of foodgrains – India

(Million tonnes)

Commodity	Supply*	Gap – 2010
Rice	88.55	-18.74
Wheat	70.78	-8.79
Coarse cereals	36.59	1.70
Total cereals	188.23	-33.52
Total pulses	14.81	-13.65
Total foodgrains	203.04	-47.17

* - Maximum output realised during 1990s was assumed as supply.

The analysis, using the demand estimates of Radhakrishna and Ravi (1990), indicates that there would be a deficit in food supply, which would amount to 47.17 million tonnes in 2010 (Table 3). This indicates that the rate of growth in domestic output should be increased to 2.11 per cent during 2010 from the present level of 1.85 per cent achieved during the 1990s (Table 4). The country has to produce an additional output of 4.72 million tonnes of foodgrain per year to meet the growing demand by 2010, from the present level of production of 203.04 million tonnes, which was the highest output recorded during 1998-99. Among the foodgrains, the

availability of pulses increased only at the rate of 0.69 per cent per annum, whereas the required rate of growth was found to be very high at 6.75 per cent by 2010. The country has to produce an incremental output of pulses at the quantum of 1.37 million tonnes per year to meet the demand in 2010. Similarly, the demand for other crops like oilseeds, cotton and vegetables is stepping up and the present production levels of these crops has to be increased to meet the growing demand.

Table 4: Required Rate of Growth to Meet the Demand – India

Commodity	2010 – per cent
Rice	1.94
Wheat	1.18
Coarse cereals	-
Total cereals	1.65
Total pulses	6.75
Total foodgrains	2.11

The required rate of growth in output was computed based on highest output as base.

India's agricultural strategy for the coming years will have to place emphasis on producing more per units of land, water, energy, time, capital and labour. Also agriculture has to be a key instrument for producing not only more food but also more income and jobs. The demand-supply estimates show that there would be a deficit in supply of farm commodities. Biotechnology may be the answer to bridge this gap. It is in this context that new genomics and molecular breeding for fostering sustainable advances in crop productivity open up opportunities. Agricultural productivity may be increased in a sustainable way through several means like use of biofertilizers, improved pest control, soil and water conservation and use of improved plant varieties of traditional or biological types. Among the various measures, biotechnology holds the most promise towards augmenting agricultural production. Research and development in biotechnology, including development, field testing and commercialisation of transgenic crops, is now recognized to be an essential and increasingly important element of a critical strategy integrating both conventional and biotechnology applications in order to achieve future food security.

Global Scenario

Globally there was a 4.5-fold increase in the area in which commercial transgenic crops were planted between 1996 and 1997, and the increase was many fold in 2000 as compared to 1996. There was a very high rate of adoption of this new technology among the farmers in the developed economies. During 1996, industrial countries accounted for 57 per cent of the global transgenic crop area, while developing countries had 43 per cent. The area of transgenic crops in industrial countries increased to 75 per cent in 1997, and only 25 per cent in developing countries. This came down to 24 per cent by 2000 (Table 5).

Table 5: Area Under Transgenic Crops

(Million ha)

Country	1996	1997	1998	1999	2000
Industrial Countrees	1.6 (57.00)	9.5 (75.00)	23.4 (84.00)	32.8 (82.00)	33.5 (96.00)
Developing Countries	1.2 (43.00)	3.3 (25.00)	4.4 (16.00)	7.1 (18.00)	10.7 (24.00)
Total	2.8 (100.00)	12.8 (100.00)	27.8 (100.00)	39.9 (100.00)	44.2 (100.00)

(Figures in parentheses denote percentages)
Source: www.agbioforum.org

Table 6: Area Under Transgenic Crops – Country-wise

(Million ha)

Country	1997	1998
U.S.A.	8.1 (74.00)	20.5 (74.00)
Argentina	1.4 (13.00)	4.3 (15.00)
Canada	1.3 (12.00)	2.8 (10.00)
Australia	0.1 (1.00)	0.1 (0.05)
Mexico	<0.1	0.1 (0.05)
Spain	0.0	<0.1
France	0.0	<0.1
South Africa	0.0	<0.1
Total	11.0	27.8

(Figures in parentheses denote percentages)
Source: Anne Simon Moffat (1998).

Worldwide, USA leads in biotechnology and nearly 75 per cent of the area is under GM (genetically modified) crops. Regulatory measures in force seem to ensure that the public has confidence in the environmental and nutritional safety of GMOs. The area under transgenic crops in USA increased to 20.5 million hectares in 1998, which is more than a two-fold increase as compared to 1997. Among the other countries Argentina and Canada made a significant breakthrough and increase in area under transgenic crops was faster in Argentina with 4.3 million hectares in 1998 as compared to 1.4 million hectares during 1997 (Table 6). Countries such as Australia, Mexico, Spain, France, China and

South Africa also made significant progress in agro-biotechnology. Besides, significant progress is foreseen from other developing countries and in India a large-scale application of this technology is expected.

Biotechnology research was conducted in the developed countries on crops of economic interest. Nearly 44 million hectares were under transgenic crops with most of the area covered by genetically modified soyabean, maize, cotton and canola (mustard) during 2000. Worldwide acreage under soyabean expanded considerably in 2000 with transgenic soyabean reaching 25.8 million hectares, corn reaching 10.3 million hectares, cotton reaching 5.3 million hectares and canola reaching 2.8 million hectares (Table 7). Efforts were also directed towards other crops like tobacco, tomato and potato and field trails are being conducted for many more crops including rice and vegetables. Incorporation of resistance to pests and diseases has been one of the major objectives of the crop biotechnology.

Table 7: Crop-wise Area Under Transgenic Crops

(Million ha.)

Crop	1996	1997	2000
Soyabean	0.5 (18.00)	5.1 (40.00)	25.8 (58.00)
Corn	0.3 (11.00)	3.2 (25.00)	10.3 (23.00)
Cotton	0.8 (29.00)	1.4 (11.00)	5.3 (12.00)
Canola	0.1 (4.00)	1.2 (9.00)	2.8 (6.00)
Tobacco	1.0 (36.00)	1.6 (13.00)	-
Tomato	0.1 (4.00)	0.1 (1.00)	-
Potato	<0.1	<0.1	-
Total	2.8	12.8	44.2

(Figures in parentheses denote percentages)

Source: James (2000)

Area under transgenic crops with herbicide tolerance increased considerably from 1996. This was less than one million hectare during 1996 and increased to 32.7 million hectares during 2000, accounting for nearly 74 per cent of the world area under the transgenic crops (Table 8). According to Kalaitzandonakes (2000) an estimated 40 per cent of the total United States corn, soyabean and cotton acreage were planted with herbicide and insect-resistant bio engineered crops in 1999, just four years from commercial introduction. Area planted to transgenic crops with herbicide tolerance showed a big jump from 0.6 million hectare in 1996 to 32.7 million hectares during 2000. Similarly, area under insect tolerance transgenic crops increased from 0.6 million hectare to 8.3 million hectares between the period 1996 and 2000.

Table 8: Traits-wise Area under Transgenic Crops

(Million ha.)

Traits	1996	1997	2000
Herbicide tolerance	0.6 (21.00)	6.9 (54.00)	32.7 (74.00)
Insect tolerance	0.6 (21.00)	4.0 (31.00)	8.3 (19.00)
Virus resistant	1.1 (39.00)	1.8 (14.00)	-
Insect tolerance and Herbicide tolerance	-	-	3.2(7.00)
Quality	<0.1	<0.1	-
Total	2.8	12.8	44.2

(Figures in parentheses denote percentages)

Source: James (2000)

Crop Biotechnology Research in India

Breeding varieties for resistance/tolerance to biotic and abiotic stresses as well as for improved nutritional qualities are particularly important to meet challenges rising from population growth and environmental and health safety cautions. During the past three decades, improvement of major crops has been achieved mainly through classical genetics and plant breeding methods. Recent advances in plant molecular biology have opened up new avenues to apply biotechnology tools for improving the conventional approaches. Increasing investment in agricultural biotechnology by both the public and private sectors is being made in India. India's emphasis has been more on agricultural biotechnology because of the need to ensure food and nutrition security for current and future populations. The application of genetic engineering to agricultural crops is to improve production efficiency and enhance environmental conservation. In India, in the Department of Science and Technology (DST) a Biotechnology Board was created in 1982. In 1986, the board was upgraded to an independent Department of Biotechnology (DBT) to give major thrust in molecular biology and biotechnology research. Currently, much of the plant molecular biology and crop biotechnology work in India has been supported by DBT.

The Department supports seven Centres of Plant Molecular Biology (CPMBs) in different parts of the country with the goal to support research and human resource development in plant molecular biology. They

are functioning at Jawaharlal Nehru University (JNU), New Delhi, Tamil Nadu Agricultural University (TNAU), Coimbatore, Madurai Kamaraj University (MKU), Madurai, National Botanical Research Institute (NBRI), Lucknow, Osmania University (OU), Hydrabad, Bose Institute (BI), Calcutta and University of Delhi, South Campus (UDSC), New Delhi. The total financial outlay for CPMBs is approximately US$ 54 million. The DBT also operates other network programmes like Development of Transgenic Cotton, (approx. US$ 13 million), Characterization of Quality Traits in Wheat (approx. US$ 12.5 million) and UNDP/FAO Support for Agriculture Biotechnology. Under DST, the institutes like Indian Institute of Science (IIS), Bangalore, Centre for Cellular and Molecular Biology (CCMB), Hyderabad and the Centre for DNA Fingerprinting and Diagnostics (CDFD) at Hyderabad also contribute significantly to the plant molecular biology area.

India has one of the world's largest public sector plant breeding enterprises functioning under the overall umbrella of the Indian Council of Agricultural Research. The Indian Council of Agricultural Research (ICAR) has established a National Research Centre on Plant Biotechnology at the Indian Agricultural Research Institute (IARI) in New Delhi. Various agricultural universities have initiated their own biotechnology programmes with funding from national and international agencies and the state governments. At present the work is being taken up on priority crops viz. rice, rapeseed and mustard, cotton, chickpea and mung bean and wheat. In addition, an emphasis has been placed on potato, vegetables (brinjal, tomato, cauliflower etc), banana, oil palm, and coconut. Three lines of molecular research have emerged from the established programmes: gene isolation, marker assisted breeding and the production of transgenic plants for resistance to biotic and abiotic stresses.

India has one of the world's largest public sector plant breeding enterprises functioning under the umbrella of the ICAR.

Insect Resistance

Synthetic *Bacillus thuringiensis* (Bt) genes have been introduced into rice for developing transgenics to resist yellow stem borer feeding (Nayak *et al.*, 1997), brinjal against fruit borer (Kumar *et al.*, 1998) and chickpea against *Heliothis armigera* (Kar *et al.*, 1997). Cowpea trypsin inhibitor gene has been introduced into chickpea for developing lines resistant to *H. armigera*. In *Brassica* sps, a project on transfer of male sterility from different sources to vegetable *Brassica*'s through protoplast fusion and incorporation of cry 1A (b) into combiner lines was implemented at IARI. In that project, the donor-recipient protoplast fusion technique was employed to transfer CMS-inducing cytoplasm into cabbage, cauliflower and broccoli. In cabbage transgenic plants were shown to carry Bt gene as evidenced by southern hybridisation of genomic DNA with Bt gene probe. Insect feeding bioassay with diamond back moth larvae confirmed that transgenic plants were tolerant to insect pests. Cry 1 A(c) gene was mobilised into *Agrobacterium tumefaciens* and was used for pigeonpea transformation to combat pod borers. The Cry 1 A(c) gene was also modified by site directed mutagenesis with a view to enhance insecticidal efficacy. The modification of Cry 1A(c) gene is in progress at UDSC. At NCL, Pune, the research on proteinase inhibitor, which is strong antifeedent to *H. armigera* feeding on cotton, is in progress.

India is also focusing on identifying and isolating novel genes from microorganisms with useful agronomic properties. For example, many institutes are engaged in isolating insecticidal genes, such as *Bacillus thuringiensis*, and the larvicidal effects of their toxin proteins, isolation and characterization of the protease inhibitor gene from cowpea, sorghum etc, amylase inhibitor genes from pulses and small grains etc.

Disease Resistance

A multi-institutional project with 12 implementing institutions is in operation from July 1999 with the financial support from DBT, Government of India. The project envisages collaboration between different labs to develop transgenics of cotton, rice, mungbean and tomato resistant to biotic stresses. The major goals are to develop transgenic plants resistant to cotton leaf curl virus, Yellow mosaic virus in mung bean, tungro virus in rice and tomato leaf curl virus (TLCV) in tomato and cucumber mosaic virus in gourds.

In another project, introducing the suitable constructs of chitinase and glucanase developed *Brassica juncea* transgenic plants resistant to fungal pathogen. Since chitinase and glucanase work synergistically, two chimeric constructs for the purpose of gene pyramiding have been made. Another project is underway on rapid clonal propagation and in vitro regeneration of Tikka disease resistant varieties of groundnut at Visva-Bharati, Santiniketan. The Indian isolates of rice tungro spherical virus (RTSV) and rice tungro bacilliform virus (RTBV) are being characterised and diagnostic probes for these viruses are being developed. Studies revealed certain important differences in the gene organisation in the In-

dian isolates as compared to the sequences available from the database. Tobacco transformation using coat protein gene of TLCV-pBI 121 construct was also done through *Agrobacterium tumefaciens*.

Quality Characters

The group at NBRI has cloned various ripening related genes from banana. The expression of these genes over the entire period of ripening shows a specific and differential pattern on Northern analysis. The antisense construct has been expressed in *Agrobacterium* as identified by probing Northern blot. At Bose Institute, an antisense RNA to delay fruit ripening in tomato had been subcloned. A transformation method using *Agrobacterium tumefaciens* was developed for tomato. Transformation of tomato using partial and full-length antisense constructs had also been initiated. Also suspension cell culture of banana was established. An efficient protocol for production of embryogenic calli from leaf bases of tissue culture grown plants had also been developed. In addition, India and Swiss are agreed for a joint research project on golden rice (pro vitamin-a gene) developed by Prof. Potrykus to address the nutritional deficiency.

Male Sterility

On hybrid seed production in mustard using barnase and barstar gene at UDSC, New Delhi, six constructs were successfully used to generate male sterile lines. The plants were allowed to set seeds under contained conditions. Single copy barstar lines both with wild type gene as well as with codon-usage modified gene driven by A 9 or TA 29 promoter were obtained. They were selfed to obtain homozygous lines. Two single copy plants were also crossed with male sterile barnase containing plants to assess their restoration capabilities. To assess the expression levels of barstar protein in different plants, antibodies against barstar protein have been developed. Besides, studies on heterosis and apomixis in crop breeding are also the subject of the study in various institutions.

Molecular Markers

In India, molecular mapping was initiated in the early 1990s. During the past one decade there has been considerable progress in molecular breeding and DNA fingerprinting in several crop applications. Molecular mapping is being used to identify markers for various biotic and abiotic stresses. Marker assisted selection laboratories are set-up in various ICAR research centres and agricultural universities. Projects on developing markers for many biotic and abiotic resistance traits in many crop plants are in progress. Mapping genes responsible for resistance to powdery mildew in pea, brown planthopper, whitebacked planthopper, stem borer and leaf folder, blast and bacterial blight resistance in rice, drought and salt tolerance in rice, the cooking quality traits and aroma characters in rice, quality characters in wheat (grain protein content and with pre harvest sprouting tolerance etc.) are some of the examples of research areas in marker development. At NCL, extensive DNA fingerprinting work for varietal identification in different crops was undertaken. At TNAU, work on DNA fingerprinting of rice varieties is in progress. Developing molecular map for chickpea and mustard was another field of study.

Molecular mapping is being used to identify markers for various biotic and abiotic stresses.

Status of Transgenic crops

Routine transformation protocols are available for *Brassica* species (mustard, cabbage, cauliflower etc), rice, chickpea, tomato, potato, brinjal, and *Vigna* species. India has developed several transgenic crops viz., Bt-transgenic pigeonpea, Bt-transgenic brinjal, and Bt-transgenic tomato. Synthetic Bt genes have been introduced into rice for developing transgenics resistant to yellow stem borer (Nayak *et al*., 1997), brinjal against fruit borer (Kumar et al., 1998) and into chickpea for developing resistance to *Heliothis armigera* (Kar *et al*., 1997). At NBRI, the cowpea trypsin inhibitor gene has been introduced into chickpea for developing lines resistant to *H. armigera*. Open field trials of Bt-tomato, Bt-transgenic cauliflower and cabbage have been conducted. India has also generated transgenic indica rice, stacked with insect and disease resistance traits; and has transformed *B. juncea* to include an antifungal gene. At MKU, attempts are on to transform two indica rice cultivars (IR-50 and ADT-36 with (pyroline-5-corboxylate synthase) p5cs gene and on development of transgenic cardamom expressing coat protein gene. At the Bose Institute, a project on metabolic engineering of inositol pathway in rice is in progress.

The significant applied work includes improving hybrids and semi-dwarf high yielding somaclonal variants of Basmati-370 rice, low erucic acid content B. juncea lines development, transgenic tomatoes and banana development with slow ripening properties with novel gene to delay fruit ripening and senescence, the Amaranthus gene introduction into rice and potato to enhance nutritional quality (Raina and Datta 1992), Bt-transgenic pigeonpea, brinjal, and tomato etc.

Table 9: Present Status of Transgenic Crop Development in India

Crop	Gene	Organisation	Traits and status
Bell pepper	Snowdrop (*Galanthus nivalis*) Lectin gene	M/s Rallis India Ltd., Bangalore	Resistance against lepidopteran, coleopteran & homopteran pests; transformation experiments in progress.
Brassica/ Mustard	Barstar, Barnase, Bar	M/s Proagro PGS (India) Ltd., New Delhi	To develop better hybrid cultivars suitable for local conditions; over 15 locations contained field trails completed.
Brinjal	Bt toxin gene Cry1A(b)	M/s Proagro PGS (India) Ltd., New Delhi	To develop plants resistant to lepidopteran pests; glass house experiments in progress.
Brinjal	Bt toxin gene	Indian Agricultural Research Institute, New Delhi	To impart lepidopteran pest resistance, transformation completed, green house trials completed and one season field completed
Cabbage	Bt toxin gene Cry1H/Cry9C	M/s Proagro PGS (India) Ltd., New Delhi	To develop resistance to pests; glass house experiments in progress
Cauliflower	Barnase, Barstar and Bar	M/s Proagro PGS (India) Ltd., New Delhi	To develop hybrid cultivars for local use; glass house experiments in progress
Cauliflower	Bt toxin gene Cry1H/Cry9C	M/s Proagro PGS (India) Ltd., New Delhi	To develop resistance to pests; glass house experiments in progress
Cauliflower	Bt toxin gene	Indian Agricultural Research Institute, New Delhi	To impart lepidopteran pest resistance, transformation completed, green house trials completed
Chilli	Snowdrop (*Galanthus nivalis*) Lectin gene	M/s Rallis India Ltd., Bangalore	Resistance against lepidopteran, coleopteran and homopteran pests; transformation experiments in progress
Cotton	Bt toxin gene Cry1A(c)	M/s MAHYCO, Mumbai	To develop resistance against lepidopteran pests; Multicentric field trials in over 40 locations completed and further contained field trails in progress
Mustard/rape seed	Bar, Barnase, Barstar	Delhi University, South Campus, New Delhi	Plant transformations completed and ready for green house experiments
Mustard/ rapeseed	Arabidopsis annexin gene	Indian Agricultural Research Institute, New Delhi	Transformation completed, Green house trial completed, ready for field-trials for moisture resistance stress
Potato	Bt toxin Gene	Central Potato Research Institute, Simla	To generate plants resistant to lepidopteran pests. Ready to undertake Green House trials.
Potato	Gene expressing for seed protein containing lysine obtained from seeds of Amaranthus plants (Ama-1 gene)	Jawaharlal Nehru University, New Delhi	Transformation completed and transgenic potato under evaluation.
Rice	Bt toxin gene	Bose Institute, Calcutta	To generate plants resistant to lepidopteran pests. Ready to undertake Green House testing.
Rice	Reporter genes like hph or gus A	Tamil nadu Agricultural University, Coimbatore	To study extent of transformation
Rice	Selectable marker genes e.g. hygromycin resistance and gus	Delhi University, South Campus, New Delhi	Gene regulation studies, Transformations completed.
Rice	Bt toxin gene	Indian Agricultural Research Institute sub station at Shillong	To impart lepidopteran resistance, transformations in progress.
Tobacco	Bt toxin gene Cry1A(b) and Cry1C	Central Tobacco Research Institute, Rajahmundri	To generate plants resistant to *H.armigera* and *S.litura*. One round contained field trial completed. Further evaluation under progress.
Tomato	Bt toxin gene Cry1A(b)	M/s Proagro PGS (India) Ltd., New Delhi	To develop plants resistant to lepidopteran pests; glass house experiments and one season contained field experiment completed
Tomato	Snowdrop (*Galanthus nivalis*) Lectin gene	M/s Rallis India Ltd., Bangalore	Resistance against lepidopteran, coleopteran and homopteran pests; transformation experiments in progress.
Tomato	Bt gene	Indian Agricultural Research Institute, New Delhi	To impart lepidopteran pest resistance, transformation completed, green house trials completed and one season field completed.

Source: www.binas.unido.org

Current transgenic crop research status by both public and private sectors in India is tabulated (Table 9). In India, regulatory mechanisms for field-testing of transgenic crops exist, based on the guidelines issued by the Department of Biotechnology and the Ministry of Environment and Forests of the Government of India.

Basic Plant Molecular Biology Research

Several works had been done on signal transduction associated with the regulation of nitrate reductase, characterization of proteins induced under abiotic stresses in rice (Pareek *et al.*, 1995), molecular biology of Agrobacterium infection (Ramanathan *et al.*,1995), isolation of homeotic genes involved with floral development in rice, sequencing of chloroplast genome of *Populus*, transcriptional control of the chloroplast genes in rice, characterization of proteins involved with DNA replication and transcription in pea chloroplast (Chen *et al.*, 1996; Tuteja *et al.*, 1996) and characterization of cytoplasmic male sterility in rice, *Brassica* species and Sorghum. A project related to nuclear organelle genome interaction is in progress. The studies related to plastid gene expression, transposable elements in crop plants and isolation of organ-specific regulatory elements from rice are in progress at different centres. Several phytochrome gene clones from wheat was also isolated. Recently, India joined in the efforts of rice genome sequencing through initiated its efforts to sequence chromosome 11.

Capacity Building

Plant molecular biology scientists were trained in developed nations either through overseas fellowships from DBT or through the Rockefeller Foundation's International programme on rice biotechnology. The Rockefeller Foundation has supported more than 200 scientists from India through various fellowships (predoctoral and post-doctoral and career) and short duration training and has made a major contribution towards developing the capacity for plant molecular work in India.

The Foundation has also supported around 30 institutes with projects to establish gene isolation, genetic transformation technology and marker assisted breeding in rice. A National Rice Biotechnology Network (NRBN) was formed in September 1991 and it paved the way for collaborative research among scientists of basic and applied areas of plant biotechnology. Besides that, the McKnight Foundation supported some research projects on plant molecular biology in chickpea.

The International Centre for Genetic Engineering and Biotechnology (ICGEB) was established in New Delhi through pursued active support from the Government of India. In that centre, plant biotechnology research is progressing well with good collaboration from various universities. For example, molecular mapping of genes conferring resistance to rice gall midge biotypes was successfully done at the ICGEB (Madan *et al.* 1997). The CGIAR institutions like the International Rice Research Institute, Philippines, International Crop Research Institute for the Semi Arid Tropics, Hyderabad, India etc also collaborate with various universities and research institutions in India to pursue research in crop biotechnology. Bhaba Atomic Research Centre, The National Dairy Development Board, Tata Energy Research Institute, SPIC Foundation, M. S. Swaminathan Research Foundation, The Maharashtra Seed Company (MAHYCO) are some of the examples of other organizations supporting programmes on plant molecular biology and molecular breeding in India.

Plant biotechnology applications also include biological control of plant pests, diseases and weeds; biofertilizers; application of tissue culture to trees and woody species; bioprospecting; medicinal and aromatic plants; sericulture biotechnology; biodiversity conservation and environment. The above-mentioned areas are also supported by DBT and significant progress has been achieved. Besides, India maintains several plant tissue repositories (or gene banks): the Microbial Type Culture Collection (MTCC) at IMTECH, Chandigarh; the National Center for Conservation and Utilization of Blue-Green Algae (NCCUBGA), at the Indian Agriculture Research Institute, New Delhi; the National Facility for Marine Cynobacterial Germplasm Collection, Bharathidasan University, Tiruchirapalli; the National Facility for Plant Tissue Repository (NFPTCR), IARI Campus, New Delhi; and the Repository on Medicinal and Aromatic Plant Materials at CIMAP, Lucknow.

The progress is in the right direction in all spheres of biotechnology including developing transgenics and map-based breeding, even though some problems are noticed. The basic infrastructure for molecular work remains weak in plant molecular biology and crop biotechnology. Many Indian agricultural universities have strong breeding programmes. Efforts are on in many agricultural universities to integrate the research efforts of crop breeders, molecular geneticists, entomologists, pathologists and plant physiologists to develop practical applications of map-based breeding. However, these programmes need involvement of scientists trained in map-based breeding. In the near future, the emerging areas of biotechnology research viz., functional genomics in crop plants, utilization of bioinformatic resources for crop improvement and proteomics research with respect to crop biotechnology are foreseen in many public and private sector research centres in India.

Expected Economic Gains

Evidence in the developed counties shows that insect resistant plants that improve yields and use less synthetic pesticides, plants that are tolerant to cold, drought or salt, and staples with improved nutritional profiles have been, or are being, developed to battle input shortfalls, production shortages, nutritional deficiencies and environmental degradation (Conko and Smith, 1999). Biotechnology also derives tangible economic benefits to the farmers in the form of cost reductions in pest management, yield improvement, improvement in risk management and insurance against pests, management time savings, reduction in equipment outlays associated with no-tillage production systems and land-use efficiency gains from improved plant spacing (Ingram, *et al*., 1999; Falck-Zepeda and Traxler, 1999; Arabiyat, *et al*.,1999).

The first field trials of transgenic crops were conducted in 1986 in the United States and France, and featured herbicide tolerance, as a marker gene in tobacco. In the decade 1986 to 1995 more than 3,500 field trials of transgenic crops were conducted on more than 15,000 individual sites in 34 countries with at least 56 crops, mostly in North America and Europe (James, 1996). Ninety-one per cent of these trials were conducted in industrialized countries, and one per cent in Eastern Europe and Russia; the balance of eight per cent were conducted in developing countries, mostly in Latin America, with only two per cent of trials conducted in the developing countries of Asia, almost exclusively in the Peoples Republic of China. The efficacy of transgenic plants was proved through estimation of increase in production and reduction in costs. The cultivation of virus, insect and herbicide resistant plants accounted for a five to 10 per cent increase in yields and savings on herbicides of up to 40 per cent and on insecticides between 60 and 120 US dollars per hectare (James, 1998).

Biotechnology in the Coming Years

The vital contribution of transgenic crops to global food, feed, and fibre security is inevitable. Adoption rate of transgenic crops in the developed economies reflects grower satisfaction due to significant benefits arising from convenient and flexible crop management, net returns and a safer environment. There is significant innovation and investment taking place in all parts of the supply chain of agro-biotechnology products. Globally, the future years are bound to see high investments on developing hybrids, varieties and genetically modified seeds, bio-fertilizers, bio-pesticides and plant growth stimulants. Genetically modified plants/seeds are expected to emerge in the coming years and would capture markets in specific sectors of the seed industry. There would also be an increase in the usage of bio-pesticides including botanical pesticides. The seeds industry alone has the potential of investing over Rs. 1.5 billion in another five years. Concomitantly opportunities exist for new investments in bio-fertilizers (over Rs. 200 million), bio-pesticides (about Rs. 300 million), pheromones, growth stimulants/ promoters (over Rs. 500 million) and botanical pesticides (James, 2000).

India is expected to emerge as a strong player in the consumption market of biotech products in the coming years. It was estimated that the consumption of these products amounted to a market value of Rs. 71540 million in 1997, of which the health care products shared nearly 37 per cent; agriculture at about 28 per cent and industrial and other products represented 35 per cent (Table 10). Consumption of such products will tend to increase in the coming years with the market value of Rs. 145600 million during 2005, of which health care products would still dominate the scene at about 40 per cent, agriculture would be at 33 per cent and other products shall constitute 27 per cent (Ghosh, 2001).

There are currently 12 to 15 major genetically modified crops produced world wide, but many more are at the development stage (Skerritt, 2000). The crop genetic transformation is taking place to improve the productivity of crops by incorporating various agronomic traits in the crops. Such crops hold promise for India since majority of the land area is under rainfed farming. Evidence also shows that productivity of crops is declining due to salinisation, particularly in the coastal area. Genetic engineering could improve the crops resistant to soil adversity like acidity, salt and toxic elements like aluminium and boron.

Table 10: Consumption of Biotech Products in India

(Rs. in million)

Particulars	1997	2000	2005
Human and health care	26370 (36.9)	35320 (37.6)	57480 (39.5)
Agriculture including seed	20270 (28.3)	28880 (30.7)	47680 (32.8)
Industrial products	24470 (34.2)	28500 (30.3)	36470 (25.0)
Other bio-tech products	430 (0.6)	1300 (1.4)	3970 (2.7)

(Figures in parentheses are percentages)

Source : Ghosh (2001)

What next?

Many questions arise about the future success of biotechnology. What are the factors driving the speedy

adoption and diffusion of transgenic crops on the farm? What are the economic benefits delivered by such technologies, and how are such benefits to be shared between the farmers and the innovators? How soon will value from quality-enhanced crops be delivered to the market? It is also equally important to know to what extent farmers should actively participate in the knowledge transformation of agriculture in order to claim a larger share of the value created by agro-biotechnology.

Many environmental groups have argued for the creation of suitable regulations to mediate the testing and release of transgenic crops to offset environmental risks and demand a much better assessment and understanding of ecological issues associated with genetic engineering. This is crucial as many results emerging from the environmental performance of released transgenic crops suggest that in the development of resistant crops not only is there a need to test the direct effects on the target insect or weed, but the indirect effects on the plant. Plant growth, nutrient content, metabolic changes, and effects on the soil and non-target organisms should all be examined. Though it was argued that agrobiotechnology is neither necessary nor sufficient for addressing the chronic food supply and nutritional problems and, that the potential environmental and food safety risks outweigh possible benefits (Altieri and Rosset, 1999), the success of agrobiotechnology depends on the realization of tangible economic and environmental benefits by agriculture. Biotechnology research on risk assessment is also crucially essential to ensure environmental safety of the transgenic crops in order to increase the large-scale adoption of GM crops.

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Feature

Private Investment in Punjab Agriculture

R.M. Herath & K.K. Jain

The green revolution in Punjab gave a fillip to farmers to make an investment in irrigation structures, farm machinery etc. This study to analyse capital formation shows that farmers continue to invest in a big way. Per hectare capital formation shows an increase, indicating scope for making additional investment on farms.

R.M. Herath is faculty at the Socio Economics and Planning Centre, Department of Agricultural, Peradeniya, Sri Lanka; and K.K. Jain is faculty at Punjab Agricultural University, Ludhiana

Growth in any sector of the economy depends upon various factors, the most important of which are capital formation in the sector, level of technology and the efficiency of the market mechanism. The same is true in the agricultural sector also and the growth potential for agricultural production depends on these factors. The agricultural sector, because of its special characteristics implying a higher degree of risk, low productivity, seasonal nature of production coupled with fluctuation in input and output prices, lacks lustre to attract investors as compared to the other sectors of the economy. However, the transformation of Punjab agriculture under the impact of the green revolution gave a fillip to the farmers to make an investment in irrigation structures, farm machinery and equipment such as tractors, threshers, seed drills reapers, harrows etc. This process of investment on such assets in which the technology is often embodied is not a onetime phenomenon but a continuous process. The investment on various capital assets varies in magnitude on different farm categories depending upon their capacity to invest and their capacity to utilise the services of these capital assets owing to the differentials in the size of holding, technology and other socio-economic factors which change over time.

Punjab is the forerunner in the adoption of new technology and plays a key role in the development of Indian economy. Hence the study related to capital formation in Punjab agriculture assumes much importance because this state, after a big jump in the green revolution, has reached a plateau in term of growth in agriculture. So a study to analyze the capital formation over time is of utmost importance.

Methodology

The study was based on the data taken from the project on "Comprehensive Scheme to Study the Cost of Cultivation of Principal Crops in Punjab" operated by the Department of Economics, Punjab Agricultural University, Ludhiana. The study selected cultivation year 2000-01 as the recent one (for which data was avail-

able), and cultivation year 1985-86 which was found to be a normal year with sufficient time gap to analyze capital formation, as two points of time. Since investment is largely affected by the cropping pattern and other socio and economic factors, it is not uniform across regions of the state. Therefore to examine the extent and pattern of investment in different areas of Punjab, the state was divided into two homogeneous zones; Zone-I and Zone-II. Zone-I is characterised by rice-wheat cropping pattern while cotton-wheat cropping pattern dominates in zone-II. To examine the change in investment on different size groups of farms, the sample holding of the comprehensive scheme for the reference years 1985-86 and 2000-01 were classified into small, medium and large size categories having operational area up to two hectares, two to six hectares and above six hectares respectively. The total number of sample holdings during the two time periods under study was 226 in 1985-86 and 250 in 2000-01. The zone-wise and size group-wise details of the sample holding at two points of time under reference is given in the Table 1.

Table 1: Size limits of farms with category of size group

Size group	Size limits of holding (ha)	Number of farmers in			
		1985-86		2000-01	
		Zone-I	Zone-II	Zone-I	Zone-II
I	Up to 2	53	35	60	40
II	2-6	56	36	60	40
III	Above 6	28	18	30	20

In agriculture, investment in farm building, irrigation structure, farm machinery and implements and livestock, which are an integral part of total farm business, constitutes the investment in fixed farm capital. Farm building includes cattle shed, implement and machinery shed and storages for farm produce and supplies. Irrigation structure and machinery constitute tube wells, bores, diesel engine and electric motors etc. Farm machinery and implements include implements used by tractors and tractor drawn implements. Livestock includes cattle, buffaloes and other animals used for draft and other milch purposes. While for investment the values of these items on first July of respective year (1985-86 and 2000-01) were estimated for each zone and size group of farm, the value of these assets added to the stock during the year constituted capital formation. The value of various assets were estimated at 2000-01 prices by adjusting 1985-86 values with the wholesale price index of 50 agricultural commodities in the state. Simple, average, weighted average, percentage and t-test were used to capture the changes over time.

Results and Discussion

Extent and pattern of capital investment

Per Farm Analysis: Investment levels on different farm groups during 1985-86 and 2000-01 on different items for two zones of Punjab are presented in Table 2. The table shows that the total capital investment increased with the increase in farm size in both the years in Zone-I and Zone-II. It is also seen from the table that total capital investment at constant prices increased over time on all the size categories of farms and zones in the state. The per farm total capital investment in 1985-86 on the small, medium and large farms and overall average farms was Rs 79996, Rs 171430, Rs 318397, Rs 170473 in zone-I and Rs. 47587, Rs 108403, Rs 275986, Rs 133946 in zone-II respectively. Similarly in 2000-01 on the small, medium, large and overall average farms, it was Rs. 90681, Rs 237555, Rs 402953, Rs 188473 in zone-I and Rs 70729, Rs 160225, Rs 280571 and Rs 150843 in zone-II respectively.

Total capital investment in zone-I increased at a faster rate on the medium farms followed by the large farms and small farms, while in zone-II total capital investment increased at a higher rate on the small farms followed by the medium farms and large farms. Since investment is a function of cropping pattern and productivity, the per farm total capital investment with respect to different zones shows that it was higher on all the size groups of farms in zone I than that of corresponding size groups of farms in Zone-II in both the years under study. This indicates that paddy-wheat rotation farmers of zone-I had more investment than that of cotton wheat farmers of zone-II and paddy wheat rotation over time had made the farmers invest more on their assets than cotton wheat farmers i.e. paddy wheat rotation had proved more beneficial to the farmers than the cotton wheat rotation. Table 2 further shows that order of magnitude of investment on different items of fixed farm assets varied across different size groups of farms, zones in the state and periods. Overall in zone-I and zone-II investment on farm machinery and implements was highest followed by livestock, farm building, irrigation structures and machinery in both years under study i.e. preference to type of investment was uniform all over Punjab.

Change in level of investment indicates that farmers of zone-I, though already having a higher level of investment in livestock, still preferred to invest more over time, while farmers of zone-II had doubled their level of investment in this sector between 1985-86 and 2000-2001. Farmers of zone-II had preferred to invest more in irrigation between 1985-86 and 2000-2001, to go for paddy cultivation wherever possible, while farmers of zone-I

Table 2: Size wise per farm investment on different items during 1985-86 and 2000-01 in Punjab

(in 2000-01 Rs)

Assets	Year	Zone-I				Zone-II			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
Farm building	1985-86	26699	41009	55428	39175	13052	26336	46101	27844
	2000-01	23792 (–10.89)	38235 (–6.70)	48792 (-11.97)	32691 (–16.55)	17730 (35.84)	35567 (35.05)	40033 (-13.16)	30211 (8.50)
Irrigation structures & machinery	1985-86	14432	24521	45045	25280	10486	18658	29867	19362
	2000-01	15176 (5.15)	31779 (29.60)	51464 (14.25)	25429 (0.59)	17915 (70.85)	29452 (57.85)	32173 (7.72)	25959 (34.07)
Farm machinery & implements	1985-86	12632	60338	166612	65570	6747	30015	149248	52681
	2000-01	20817 (64.79)	116964 (93.85)	233936 (40.41)	86784 (32.35)	13935 (106.54)	66186 (120.51)	160153 (7.31)	64637 (22.70)
Livestock	1985-86	26233	45562	51312	40268	17302	33394	50770	34059
	2000-01	30896 (17.78)	50577 (11.01)	68761 (34.01)	43569 (8.20)	21149 (22.23)	29055 (-12.99)	48212 (-5.04)	30036 (-11.81)
Total	1985-86	79996	171430	318397	170473	47587	108403	275986	133946
	2000-01	90681	237555	402953	188473	70729	160265	280571	150843
	Increase	10685 (13.36)	66125 (38.57)	84556 (26.56)	18000 (10.56)	23142 (48.63)	51862 (47.84)	4585 (1.66)	16897 (12.61)

Figures in parenthesis indicate percentage increase over 1985-86.

had preferred to still invest most in farm machinery and implements during this period.

Per Hectare Analysis

The per hectare estimates of capital investment on different size groups of farms in the state are presented in Table 3. It can be seen from the table that the per hectare total capital investment at constant prices increased significantly over time on all the size groups of farms in the state. Table 3 further reveals that the per hectare total capital investment with farm size in zone-II in 1985-86, but level of investment as compared to zone-I indicated relatively poor capital base of farmers specifically of small farmers in this zone. In 2000-01 in both zones the medium farms had the least investment and the small farms had the highest per hectare total capital investment, which may be attributed to better economy of indivisible resources on medium farms.

With regard to the extent and changes in the per hectare investment on different items of fixed assets between the two points of time under study, Table 3 shows that the per hectare investment, except on farm machinery and implements decreased with an increase in the farm size on all farm situations in the state. Investment on farm buildings on per hectare basis at constant prices showed a decline in 2000-01 over 1985-86 on all size groups of farms in zone-I while on all the size groups of farms in zone-II it increased in 2000-01 over 1985-86. Investment in irrigation structures and machinery because of the indivisible nature of these assets was higher on per hectare basis on the small farms as compared to the large farms in both zones. Investment in irrigation structures and machinery increased over time on all the size groups of farms in the state. Increase was higher in zone-II as compared to zone-I indicating stress on investment in this sector in zone-II was towards irrigation intensive paddy crop. The area in this zone had increased by 36 per cent (Herath; 2004) between these two years. The per hectare investment in farm machinery and implements at constant prices increased with an increase in farm size in both zones of the state and showed an increase over time on all the size groups of farms in the state due to increased level of mechanization of farm operation. With respect to the investment on livestock Table 3 shows that the per hectare investment on livestock decreased with an increase in the farm size in the state. It is also seen from the table that investment in livestock increased over time in all the size groups of farms except on medium farms in zone-II. Level of investment on large versus small indicated its preference and concentration on small farms. Thus the promotion of this sector through financial agencies on this size group can reduce the disparity and increase the well being of much of the population.

Table 3: Size wise per hectare investment on different items during 1985-86 and 2000-01 in Punjab

(in 2000-01 Rs)

Assets	Year	Zone-I				Zone-II			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
Farm building	1985-86	18892 (33.11)	9971 (23.91)	6789 (17.43)	12263 (26.62)	6540 (27.43)	5891 (24.17)	4770 (17.00)	5919 (23.32)
	2000-01	16730 (27.32)	8661 (16.22)	6671 (12.27)	12322 (21.47)	11559 (25.47)	8650 (22.19)	5824 (14.26)	9157 (22.66)
Irrigation structures & machinery	1985-86	10212 (18.04)	5962 (14.28)	5516 (14.28)	5516 (14.17)	7265 (15.78)	5254 (22.03)	4174 (17.20)	3090 (11.02)
	2000-01	10671 (13.30)	7199 (12.72)	7036 (11.60)	8125 (12.87)	11679 (24.12)	7163 (18.37)	4680 (11.46)	7966 (19.71)
Farm machinery & implements	1985-86	8939 (15.79)	14671 (35.15)	20456 (52.41)	13929 (30.24)	3380 (14.18)	6714 (27.54)	15447 (55.04)	7959 (31.47)
	2000-01	14637 (23.90)	26497 (49.61)	31996 (58.84)	21486 (37.45)	9084 (20.02)	16097 (41.29)	23302 (57.08)	13926 (34.45)
Livestock	1985-86	18563 (32.80)	11137 (26.68)	6221 (15.98)	12597 (27.32)	8668 (36.36)	7595 (31.15)	4754 (16.94)	7296 (28.74)
	2000-01	21725 (35.48)	11557 (21.46)	9401 (17.29)	16137 (28.20)	13788 (30.39)	7066 (18.13)	7013 (17.19)	9369 (23.18)
Total	1985-86	56606	41741	38982	46054	23842	24373	28061	25349
	2000-01	63763*	53914*	55104*	58300*	46110*	38976*	40819*	40418*

Figures in parentheses are per cent to total.

* indicates significantly different from 1985-86 at 0.05 probability level.

Analysis of composition of fixed assets indicates that on the small farms in zone-I in 1985-86, investment on farm buildings was highest and was followed by livestock, irrigation structures and machinery, farm machinery and implements, but in 2000-01 investment on livestock stood at first place followed farm building, farm machinery and irrigation structures. On the small farms in zone-II in both years under study, livestock occupied the first place followed by farm building, irrigation structures and machinery and farm machinery and implements. This trend in investment highlights the increasing relative importance of dairying sector on small farms in the state. This is because small farmers have taken dairying to supplement their farm income. On the medium farms in zone-I in both years under study, investment on farm machinery and implements was the dominant item of investment followed by livestock, farm building and irrigation structures and machinery. In zone-II on the medium farms in 1985-86, investment on livestock occupied the first position followed by farm machinery and implements, farm buildings and irrigation structures and machinery. But by 2000-01 farm machinery and implements came to the first place followed by farm building, irrigation structures and machinery and livestock. This trend in investment over time on medium farm in zone-II seemed to be linked with reducing investment on draft animals and increasing more and more farm machinery and implements. In case of the large farms in both zones in 1985-86 investment on farm machinery and implements was highest followed by farm building, livestock, irrigation structures and machinery. While in 200-01, farm machinery and implements remained as the dominant item of investment, livestock became the second most important item of investment. On the overall average farms in zone-I and II in both years under study, investment on farm machinery and implements was highest followed by livestock, farm building irrigation structures and machinery. This may be due to the fact that ownership of farm machinery not only facilitates timely farm operation but also increases social image.

Pattern and magnitude of capital formation

To examine the changes in the pattern of capital formation on different categories of farms in the state, capital formation in term of different fixed assets was estimated for each zone and size groups of farms during 1985-86 and 2000-01 and the estimates are presented in Tables 4 and 5. Table 4 shows that the per farm total capital formation in both zones during 1985-86 and 2000-01 at 2000-01 prices. During 1985-86, total capital formation was highest on the medium farms followed by large and small farms. During 2000-01, the per farm total capital formation in zone-I held negative association with farm size i.e. small farms were putting more investment in productive assets during the year as compared to other farms. Table 4 further shows that

Table 4: Size-wise per farm capital formation during 1985-86 and 2000-01 in Punjab

(in 2000-01 Rs)

Assets	Year	Zone-I				Zone-II			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
Farm building	1985-86	1316 (4.93)	1130 (2.75)	–	967 (2.47)	817 (6.29)	264 (1.00)	302 (0.66)	405 (1.45)
	2000-01	833 (3.50)	1183 (3.09)	–	841 (2.57)	–	–	–	–
Irrigation structures & machinery	1985-86	1679 (11.63)	2359 (9.62)	1516 (3.36)	1868 (7.39)	–	1244 (6.67)	778 (2.60)	836 (4.32)
	2000-01	2196 14.47)	6283 (19.77)	1214 (2.36)	4193 (16.49)	375 (2.09)	2574 (8.74)	1000 (3.11)	2404 (9.26)
Farm machinery & implements	1985-86	5512 (43.63)	13033 (21.60)	8916 (5.35)	8365 (12.76)	257 (3.81)	6706 (22.34)	1537 (1.03)	3993 (7.58)
	2000-01	19465 (93.50)	14618 (12.50)	7115 (3.04)	15907 (18.33)	1877 (13.47)	6359 (9.61)	1640 (1.02)	4782 (7.40)
Draft animals	1985-86	217 (6.25)	396 (6.31)	869 (14.49)	431 (8.26)	289 (12.03)	519 (6.65)	183 (2.09)	384 (5.70)
	2000-01	186 (17.76)	336 (43.86)	805 (48.70)	330 (32.01)	269 (54.34)	411 (63.72)	182 (13.63)	351 (32.96)
Milch animals	1985-86	3035 (14.83)	2955 (8.37)	3150 (7.84)	3019 (9.61)	1555 (11.88)	3079 (13.31)	3199 (8.54)	2744 (11.37)
	2000-01	3950 (15.53)	2935 (6.91)	4389 (7.69)	3604 (9.94)	3975 (22.86)	5232 (22.30)	7747 (20.84)	5239 (22.04)
Total	1985-86	11759 (14.70)	23398 (13.65)	15706 (4.93)	16570 (9.72)	6556 (13.78)	11485 (10.59)	6812 (2.47)	8957 (6.69)
	2000-01	26630 (29.37)	25355 (10.67)	13523 (3.36)	24875 (13.20)	15871 (22.44)	22076 (13.77)	10569 (3.77)	19610 (13.00)

Figures in parentheses indicates per cent to total.

small farms in both zones added to their existing inventory at higher rate than the other farms. This is due to existing low capital base of these farms. It is also seen from the table that except the large farms in zone-I, there was an increased level of capital formation during 2000-01 as compared to capital formation during 1985-86 on all the size groups of farms, indicating that there is desire and scope for making additional investment on these farms. Similar to the per farm total capital investment as seen in Table 2, the per farm total capital formation during both the years under study was higher on all the size groups of farms in zone-I as compared to zone-I, which is attributed more to rice wheat cropping pattern and resources endowments of this zone, than that of corresponding size groups of farms in zone-II. With regard to the magnitude of capital formation in term of different fixed assets on different size groups of farms. Table 3 further shows that capital formation is unequally distributed across different size groups of farms and zones in the state.

The per hectare capital formation in terms of different items on different size groups of farms in the state is presented in Table 5. It can be seen from the table that the per hectare total capital formation at constant prices showed an increase in 2000-01 as compared to 1985-86 in all the size groups of farms, reflecting the scope for making additional investment on Punjab farms. Table 5 further shows that the per hectare total capital formation increased more sharply on the small farms in both zones followed by medium and large farms in zone-I and large farms and medium farms in zone-II. The per hectare total capital formation at constant prices decreased with an increase in the farm size during both the years in zone-I and during 2000-01 in zone-II, but during 1985-86 in zone-II no such trend was exhibited.

A look at the capital formation in terms of different capital items indicates that capital formation in terms of farm building on per hectare basis at constant prices showed a decline in 2000-01 over 1985-86 in all the size groups of farms in the state. Capital formation in terms of irrigation structure and machinery and farm machinery and implements, showed an upward trend over time on all the size groups of farms in zone-II and on the small and medium farms in zone-I, but on the large farms in zone-I it showed a decline in 2000-01 over

Table 5: Size wise capital formation per hectare during 1985-86 and 2000-01 in Punjab

(in 2000-01 Rs)

Assets	Year	Zone-I				Zone-II			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
Farm building	1985-86	931 (11.09)	274 (4.82)	–	435 (9.02)	409 (19.32)	59 (2.20)	31 (4.41)	136 (6.55)
	2000-01	585 (3.12)	268 (4.67)	–	384 (3.29)	–	–	–	–
Irrigation structures & machinery	1985-86	1187 (14.28)	573 (10.09)	184 (9.62)	697 (14.48)	–	278 (10.38)	80 (11.38)	165 (7.94)
	2000-01	1544 (8.24)	1422 (24.87)	165 (8.98)	1446 (12.39)	244 (2.36)	625 (18.29)	145 (9.44)	619 (9.35)
Farm machinery & implements	1985-86	3090 (46.89)	3169 (55.70)	1091 (56.81)	2014 (41.76)	128 (6.09)	1499 (55.99)	158 (22.62)	855 (41.18)
	2000-01	13687 (73.09)	3310 (57.90)	972 (52.62)	8050 (68.99)	1224 (11.80)	1596 (26.57)	238 (15.49)	1206 (18.21)
Draft animals	1985-86	153 (1.84)	97 (1.70)	105 (5.96)	117 (2.43)	144 (6.81)	115 (4.29)	18 (2.56)	100 (4.82)
	2000-01	131 (0.70)	75 (1.31)	110 (5.95)	108 (0.93)	176 (1.70)	115 (1.97)	26 (1.69)	120 (1.81)
Milch animals	1985-86	2147 (25.80)	718 (12.62)	385 (20.03)	1120 (23.24)	779 (36.82)	689 (25.72)	331 (47.08)	625 (30.12)
	2000-01	2778 (14.85)	642 (11.23)	600 (32.45)	1680 (14.40)	2592 (25.08)	1272 (21.87)	1127 (73.38)	1700 (25.66)
Total	1985-86	7508 (14.26)	5688 (13.63)	1920 (4.92)	4820 (10.46)	2115 (8.87)	2678 (10.99)	702 (2.50)	2076 (8.19)
	2000-01	18725 (29.37)	5717 (10.60)	1847 (3.35)	11668 (20.01)	10348 (22.44)	3626 (9.30)	1536 (3.76)	6626 (16.39)

Figures in parentheses are per cent to total while under total in parentheses represent per cent to capital base.

1985-86 indicating that the large farms in zone-I had already made enough investment on these assets. With respect to the capital formation in terms of draft and milch animals, Table 5 shows that the per hectare capital formation in terms of draft animals increased marginally over time on the large farms in zone-I and on the small and large farms in zone-II, while it declined over time on the small and medium farms in zone-I. Except on the medium farms in zone-I, capital formation in terms of milch animals at constant prices, as is evident from Table 5, increased during 2000-01 as compared to capital formation made in this sector during 1985-86 on all the size groups of farms in the state, indicating the importance of the livestock sector in Punjab agriculture.

Analysis of the structure of capital formation reveals that on the small farms in zone-I during both the years under study capital formation in terms of farm machinery and implements was the dominant item accounting for 41 and 73 per cent of total capital formation during 1985-86 and 2000-01 respectively, followed by milch animals, irrigation structures and machinery, farm building and draft animals. But on the small farms in zone-II during 1985-86, milch animals constituted the highest proportion of total capital formation (53%) followed by farm building, draft animals, farm machinery and implements and irrigation structures and machinery. During 2000-01, capital formation in terms of milch animals remained as the dominant item followed by farm machinery and implements, irrigation structures and machinery, draft animals and farm buildings. This indicates the tendency towards mechanization of farm operation over time on small farms. In case of medium farms in zone-I during 1985-86, farm machinery and implements were the most important items sharing about 65 per cent of total capital formation, followed by milch animals, irrigation structures and machinery, farm building and draft animals. While during 2000-01 farm machinery and implements remained as the dominant item, irrigation structures and machinery occupied the second position. On the medium farm in zone-II during both the years capital formation in terms of farm machinery and implements was highest and was followed by milch animals, irrigation structures and machinery, draft animals and farm buildings. On the large farms in zone-I during both the years under study,

Table 6: Size wise per hectare incremental capital-output ratios during 1985-86 to 2000-01 in Punjab

(in 2000-01 Rs)

Capital/Value Output	Year	Zone-I				Zone-II			
		Small	Medium	Large	Overall	Small	Medium	Large	Overall
Capital	1985-86	56606	41741	38982	46054	23842	24373	28091	25349
	2000-01	63763	53914	55104	58300	46110	38976	40819	40418
Incremental Capital		7157	12173	16122	12246	22268	14603	12758	15069
Value product	1985-86	55242	58295	68705	59369	30656	40059	53913	41127
	2000-01	64689	80247	79162	72472	88264	67412	62177	73559
Incremental Value product		9947	21952	10457	13103	57608	27353	8264	32432
Incremental Capital value Product ratio		1.32	1.80	0.65	1.07	2.59	1.87	0.65	2.15

farm machinery and implements remained as the dominant item, followed by milch animals, irrigation structures and machinery, draft animals and farm building. But the large farmers in zone-II made more investment on milch animals during 1985-86 followed by farm machinery and implements, irrigation structures and machinery, farm building and draft animals and during 2000-01 capital formation in terms of milch animals continued as the most important item, raising its share to 73 per cent followed by farm machinery and implements, irrigation structures and machinery, draft animals and farm building.

Efficiency of Capital Investment

The efficiency of capital investment is as important as capital formation. The efficiency of capital investment was analyzed by working out incremental capital-output ratios for each zone and size group of farms during the period of time from 1985-86 to 2000-01.

The results given in Table 6 indicate that the incremental capital-output ratios were positive and greater than unity on small and medium farms in both zones, indicating that these farms were more efficient with respect to the use of fixed capital. Corresponding to this, the large farms in the state were inefficient in use of capital assets.

The zone-wise comparison showed that incremental capital output ratio was higher in zone-II than in zone-I, which is ascribed to the fact that due to increase of 36 per cent in area under paddy, value of output in this zone increased at a high rate.

Conclusions and Policy Implications

The study shows that private investment on farm has grown in all farm situations in the state where the small farms in zone-I and large farms in zone-II show relatively low increase in investment over time. The relatively high increase in investment on farm machinery and implements indicates that the farmers continue to invest in a big way in farm machinery and implements over time. The relatively high increase in investment on farm machinery and implements indicates that the farmers continue to invest in a big way in farm machinery and implements over time. However the structure of investment showed an increasing relative importance of dairying sector on small farms in the state. This trend needs to be encouraged as small farmers would be able to supplement their meagre income through the dairy sector.

The study further reveals that the per hectare capital formation shows an increase during 2000-01 as compared to 1985-86 in all the size groups of farms, indicating scope for making additional investment on farms. The highest increase in per hectare capital formation is observed in case of small farms in the state. As far as efficiency of fixed of capital is concerned all size groups except large farms are efficient with respect to the use of fixed capital.

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Feature

Prospects, Problems and Scope of Rice Production in Northeast Hilly States of India

K.K. Datta, A.K. Khan, S.B. Singh, A.K. Tripathi & S. Mandal

In India, prioritizing production constraint research is mainly confined to biotic and aboitic constrains, leaving aside socio-economic issues. Efforts have been made to identify production constraints that cause significant production losses, and to rank these constraints in terms of their impact on production losses. On the basis of constraint in rice-based production system under the rainfed hilly eco-system in NEH, the study tried to explore researchable issues.

K.K. Datta, A.K. Khan, S.B. Singh, A.K. Tripathi & S. Mandal are all faculty at ICAR Complex for NEH, Meghalaya.

In the past major attention was attached to the better-endowed areas for better production, and this approach paid dividends. But recently the country has reached near saturation for production in irrigated area. Evidence suggests that future growth in Indian agriculture lie in the rain-fed areas, which occupy a large portion of about 90 million ha.

The agricultural production system in the north eastern hill (NEH) region of India is mostly rainfed, mono-cropped and at a subsistence level. Shifting cultivation of the region is more traditional and it is a culturally integrated form, which is an ecologically and economically viable system of agriculture as long as the population density is low. The region has the stigma of low and uncertain productivity, slow and poor dissemination of new technologies, a large concentration of poor people, high level of degradation of natural resources, including biodiversity, as well as poor infrastructural facilities. In such an environment, the yields are not only low but also fluctuate abnormally. In other words, there is no significant improvement in the productivity of foodgrains in such harsh environments of the rain-fed area. Although the rainfed region is lagging far behind irrigated and other favourable regions, this region has a considerable potential as it possesses fairly good soil, humus, high precipitation, enough human resource, large cattle population etc. In order to exploit such a potential rainfed eco-system, the Indian Agricultural Research system through its R&D programme places very high priority to this lagging eco-region with multiple goals of enhancing production potential, improving social welfare, controlling degradation of natural resources and exploring opportunities for crop diversification.

Among several research initiatives, the Indian Council of Agricultural Research (ICAR) has carefully delineated the rain-fed eco-system among five agro-

ecosystems in India for target and client-oriented research and technology transfer. Like other agro-ecological regions, the rainfed eco-region is constrained by a large number of factors in enhancing agricultural productivity, adopting improved technologies and conserving natural resources, largely because resources for research are scarce and production constraints are numerous. Therefore, it is necessary to prioritise the severity of the problem. Such as exercise is essential for the judicious use of the scarce resources for agricultural research.

In general the common opinion is that the introduction of modern package of practices along with high-yielding varieties will help to increase productivity particularly in paddy. In the NEH region, about 45 per cent of the cultivated area is under HYV. But the introduction of exotic paddy HYV varieties in the north-eastern region shows that instead of increasing productivity of paddy, these varieties demanded higher inputs. The resultant outcome is growth of intensive foliage and the higher nutrient contents of the plants become a good host for insect pests and disease pathogens. Along with this problem, congenial climatic conditions like high rainfall, higher humidity throughout the year doubled the problem of pest infestation. It has been observed that cultivation of some of the blast resistant varieties under poor nutrient management conditions, helps to increase the incidence of brown leaf spot. Concerns are also raised about increased evidences as well as emergence of new insect pests and disease pathogens that are generally reported from the northeastern hill region (NEH) and the ultimate consequence on the productivity of rice.

Attempts have been made in this study to identify a production constraint that causes significant production losses, and to rank these constraints in terms of their impact on production losses. The present study also explores the researchable issue in the paddy-based production system under the rainfed hill agro-ecosystem in northeastern hill region of Meghalaya, Nagaland and Tripura, based on the constraint prioritization.

A perusal of the literature shows that lots of work has been done both in the irrigated (Roy & Datta, 1999) and rain-fed (Ramaswamy et al, 1996; Widawsky and O'Toole, 1996) eco-system. But prioritizing production constraint research in India is primarily confined to the rain-fed rice system and that too for biotic and abiotic constraints, leaving aside socio-economic issues. Earlier studies on the constraint analysis also suffer from another limitation in that they use the state boundary rather than agro-ecological regions or sub-regions as the target domain. Those studies have seldom identified homogeneous production zones where the constraints were of more or less similar in nature and where research outputs have homogeneous impacts. But in the hilly region of NEH, rich production zones were heterogeneous in nature due to its undulated topography and very low solar radiation throughout the growth process of rice production. In the mid-altitude cold is the major constraint during flowering stage, and similarly in the high altitude cold is the major constraint both at vegetative as well as flowering stage.

Need for prioritization

Farmers who are the ultimate clients of agricultural research output, usually face a large number of production-related constraints. Identification of the technology needs of the users, and translating these needs into research programmes is an essential component of production system research. If properly attempted, a clear set of research themes will emerge for the most important problems. However, these constraints as well as research needs vary considerably across production systems and sub-systems. Identification of location–specific production constraints for various production systems and their prioritization is the first step for any need-based research. Similarly, to undertake a more focused research programme in agriculture, it is necessary to identify the research domain. Once the zones are identified the new technology can be expected to have a relatively homogenous impact and thus the need of farmers must be translated into research alternatives. Such an exercise is also essential for the judicious use of scarce resources for agricultural research. Until now, the decision regarding research resource allocation was based on the judgments of the decision-makers, which were subject to natural human bias. Now it is being felt that every rupee invested in agricultural research should be based on well-evaluated and properly prioritized programmes so that it can yield maximum returns.

Database and methodology

The household level information on various aspects of production and production constraints were collected with the help of questionnaires for the agricultural year 2002-03. To supplement these agro-biological scientists, already working on various aspects of the paddy-based system, were contacted for detailed discussion and an exhaustive list of constraints were prepared. Subsequently, constraints with economic significance were short-listed, for which information was gathered from a household survey. The technical constraints for crops are categorized as:

1. Insect and pests
2. Diseases

3. Soil-related problems

4. Weeds

5. Water-related problems

6. Others (physiological/agronomic)

The severity of each constraint was assessed through estimation of yield loss. The average absolute quantity of yield loss attributed to each constraint was estimated from the response given by the farmers and the same was crosschecked by the scientists and extension personnel. The farmers were also asked to estimate the proportion of area affected for the crop by each constraint and the probability of occurrence of a particular constraint on the basis of past experiences. Estimates of samples made from households and also the constraints were then averaged for the crop. Total yield loss was calculated from these averages. The average yield loss multiplied by area affected and subsequently by the prices of a particular crop, provided the value of production. It is important to note here that a farmer might come across lots of problems during the production of a particular crop. Total yield loss was calculated from these averages. The average yield loss multiplied by area affected and subsequently by the prices of a particular crop, provided the value of production. It is important to note here that a farmer might come across lots of problems during the production of a particular crop. However, it is quite obvious that all production constraints do not occur together and do not affect the entire region at once. The extent of damage caused by a particular constraint may vary from one region to another. Similarly, the proportion of area affected by a particular constraint and its probability of occurrence in a year may also differ. The extent of maximum damages if added together to estimate the extent of maximum yield loss, would lead to a misleading picture. Hence, it would be quite logical to convert the extent of maximum damage, during the period of occurrence of a particular constraint, into the stream of average annual yield loss after considering its probability of occurrence and proportion of affected area. The procedure for calculating production loss is given as:

$$\Phi = \mathbf{n} \cdot \mathbf{p} \cdot \mathbf{I}$$

where,

Φ = average yield loss attributed to each constraint (kg/ha)

n = proportion of area affected (%)

p = probability of occurrence of a particular constraint (%)

I = absolute yield loss attributed to each constraint (kg/ha)

$$\eta = \Phi \cdot \mathbf{N}$$

where,

η = total production loss ('0000 tonnes)

Φ = as explained above

N = area under individual crop in target area (million ha.)

$$\mathbf{Z} = \eta \cdot \mathbf{P}$$

Where,

Z = value of production loss (Rs. in million)

η = as explained above

P = price of output (Rs./kg)

Prioritising socio-economic constraints is more difficult. Crop-wise analysis was not possible as the same set of constraints affected the entire region irrespective of crops or cropping systems. Therefore, cardinal measurement of their impact on yield gap could not been tried. However, the farmers were asked to rank the constraints as per their severity. A comprehensive list of socio-economic constraints were given to them and they were asked to assign value one to the most limiting constraint, two to the next important one, and so on. Then the rank values were averaged across the villages and a composite score was obtained on the basis of which top ten socio-economic constraints were prioritised.

Since the yield of the hill region varies between lowland and upland and between *jum* land and valley land, proper weightage has been given during the process of reporting yield on the basis of percentage of area (under different system). In this study, yield gap II. The yield gap I is the difference between an experiment station's average yield and an on-farm experiment's average yield. It arises from differences in environment that cannot be managed in the farmer's field. Yield gap II, which is the primary concern of the present study, is the difference between actual farm yield and the yield attained in on-farm experiments. This gap reflects various biotic, abiotic stresses and socio-economic constraints.

Performance of agriculture in the NEH region

Cropping pattern in northeastern hill states, except Sikkim, remained highly specialized in foodgrains and yet there is a deficiency in foodgrains. In Arunachal Pradesh, Meghalaya, Mizoram, Nagaland and Tripura, pulses and oil seeds gained area mainly through a shift away from rice. Unlike other states, Sikkim experienced a drastic decline in area under foodgrains crops, the

reason being diversification towards horticultural crops and spices. There was a low to moderate increase in cropping intensity in most of the northeastern states. In case of rice, there was significant growth in area in Arunachal Pradesh and Nagaland, while other states showed negative growth rates. Despite the declining area under rice, production could be increased significantly due to the improvement in productivity. In Meghalaya, the production of rice decreased by 0.16 per cent per annum due to a decline in both area and productivity. Mizoram experienced the highest growth rate of 7.5 per cent per annum mostly by increasing productivity. However, in Arunachal Pradesh the increased production was mainly due to area expansion. In totality, the foodgrain production in Manipur, Mizoram, Sikkim and Tripura increased significantly mostly due to the improvement in productivity, whereas in other states it was due to only area expansion.

Rice and maize are the major cereal crops in this region. All the farmers prefer to grow rice, as it is their staple food crop. Rice production in NEH in general is consumption-oriented to cater to the needs of the farmers and local population and not for marketing. Under the traditional procedures for growing rice, the choice of alternatives open to a farmer is extremely limited. Since economics involves the comparison of choice among alternatives, there are few economic decisions to be made in this subsistence environment. The yield of paddy for different states in the NEH region is given in Table 1. In NEH, out of 49 rice growing districts, in 4 districts the productivity of rice is more than 2500 kg, in another 4 districts, the range of rice productivity is between 2000-2500 kg, in 13 districts productivity of rice is in the range of 1500-2000 kg/ha, in 22 districts it is about 1000-15000 kg and in 6 districts the productivity of rice is less than 1000 kg.

Table 1: Area, production and yield of paddy crop in NEH Region (2002-03)

States	Area ('000 hectare)	Output ('000 tonnes)	Yield (Kg/ha)
Arunachal Pradesh	120	134	1119
Sikkim	15	21	1415
Manipur	198	428	2320
Meghalaya	108	191	1772
Mizoram	57	109	1912
Nagaland	156	250	1630
Tripura	256	588	2297
Total NEH	3497	5480	1711
All India	33359	84871	1913

Source: Basis Statistics of NER, 2002, E & M Cell, Govt. of India, North Eastern Council Secretariat, Shillong-793001

The average yield of paddy in northeastern hill region of India is miserably poor compared to other states of the country. In 2002-03 the yield obtained was 1567 kg/ha as compared to average of 1913 kg/ha. Paddy yield fluctuates enormously particularly in the hilly environment. Yet it is accepted as an important crop as it meets the food requirement. The productivity gain in paddy has been insignificant mainly due to cultivation in marginal lands and absence of major breakthrough in the development of management practices and non-availability of input responsive crop varieties. The area under paddy has remained stagnant. In 1990-91 the area under paddy in NEH region was Rs 3.3 lakhs hectare whereas in 2002-03 it is around Rs 3.5 lakhs hectare. However the production fluctuated abruptly because of erratic distribution of rainfall. Thus the paddy yield fluctuated from 1959 to 2129 kg/ha and consequently the total production also varied from 4.5 MT to 5.5 MT. Paddy is an exhaustive crop that utilizes large quantities of nutrients from soils resulting in nutrient deficiencies. These deficiencies are probably associated with factors like low and declining level of organic carbon as well as decreasing use of organic manure and irregular use of fertilizers.

Trends in area, production and yield of rice

Table 2 gives the estimated trend of growth rates in area, production and yield of paddy in the NEH region. To place the growth in NEH in the proper perspective, the comparative growth rates for India are also given. All the trend growth rates, except for production in NEH region, are statistically significant. It is seen from Table 2 that there has been a gradual increase in area, production and productivity of this crop over the last three decades. The Northeastern region accounts for 7.81 per cent of total area under rice and shares 6.07 per cent of the total rice production in India. But average per hectare yield of rice in the region (1567 kg) is far below the national average (1913 kg). Out of seven states in the Northeast, four states have shown positive trends and three states have shown negative trends in growth of area under rice. Except Arunachal Pradesh and Nagaland, the growth rates of area in other states of the region were significantly low (less than 1 per cent) (Table 2).

Table 2 also reveals that even under the harsh environmental situation and the trend of declining/negative yield growth, there has been a persistent increase in acreage under this crop and the largest expansion came during the 1980s when the yield started declining. This expansion in area appears to be a result of an extension of *jhum* area and settled cultivation in the region. It has replaced basic cereal crops, which might have higher social desirability.

Contributions of area in increasing rice production were appreciable in the states of Arunachal Pradesh, Meghalaya and Nagaland. Average yield was the sole contributing factor in increasing rice production in the states of Manipur, Mizoram and Tripura (80, 139 and 101 per cent respectively). In Mizoram and Tripura, the significant yield effect offset the negative area effect. Area and average yield contributed almost equally in increasing the rice production in Assam.

The average percentage area under high yielding varieties for Northeast India being 50.42, was far below the national average of 65.90 per cent. In the higher growth states of Mizoram, Tripura and Manipur, the percentage varied from 37.5 to 73.55. It reveals that area under high-yielding varieties have a direct bearing on the productivity of rice in the region.

Mizoram and Tripura states, which were the centres of high productivity growth, had the highest percentage changes in proportion to the net-irrigated area (33.93 and 21.60 per cent, respectively). Percentage change in fertilizer use per hectare was also high in Mizoram and Tripura States. This suggests that fertilizer use had almost a complementary relationship with the availability to irrigation facilities which finally helped to increase rice productivity. Similarly, the availability of credit was highest in Mizoram, the least being in Arunachal Pradesh state.

In Northeast India, the maximum variation in rice production was observed in Mizoram (45.47%) and the minimum in Meghalaya (8.54%). These two states also showed the highest, and lowest growth rates of rice production in the region. It revealed that the states with higher growth rate of yield per hectare also witnessed high instability in rice production.

Table 2: Trends in area, production and yield growth of paddy in NEH Region

States	Area	Production	Yield
Arunachal Pradesh	3.26**	4.15**	1.12**
Manipur	(–)0.39*	1.77**	2.08**
Meghalaya	0.14 ns	(–)0.24 ns	(–)0.36 ns
Mizoram	(–)0.44 ns	4.10**	4.40**
Nagaland	2.78**	4.04**	1.52**
Tripura	(–)0.85**	2.22**	3.08**
North East India	0.73**	2.40**	1.61**
All India	0.53*	3.13**	2.58**

* Significant at 5 per cent level; **Significant at 1 per cent level; ns = Non Significant.

Another observation is that the states of NEH with higher productivity growth rates had a relatively lower size of holdings. For instance, the average size of holding in the leading growth states of Mizoram, Tripura and Manipur ranged from 0.97 to 1.38 hectares as against 1.77 to 6.82 hectares in the low growth states of Meghalaya, Arunachal Pradesh and Nagaland.

This yield gap data in Table 3 indicates that there is a vast untapped reservoir existing at current level of technology, exploitation of which can help in raising productivity. Diagnostic surveys have been conducted and some constraints have been identified in few pockets but those studies failed to quantify the magnitude of losses arising from this set of constraints. Information is inadequate which could form the base to prioritize the production constraints in the Northeastern hill region.

As expected, the yield gap in terms of percentage in Table 3, is smaller in Manipur (85%) where one expects to find modern varieties, high inputs and assured irrigation to a large extent. The highest yield gap in percentage terms occurs in Nagaland (144%), which is grown mainly under stress situation, in marginal lands and is susceptible to a wide range of pests and diseases. The average yields obtained by the farmers, in almost all the situations, are less than half of experiment station yield and yield gap II, like yield gap I, is also very large. This supports the view that though the HYVs started with a premise that their performance would be superior even under stress condition, but since they demand more nutrients their performance in low fertility condition is inadequate. The yield gap statistics suggest that a large potential exists, which can be managed by exploiting the potential of existing technologies and/or by replacing them with some more appropriate, need-based technologies.

Once the yield gaps are known, the next step is to identify the composition of the gap in terms of biotic, abiotic and socioeconomic constraints and measure the contribution of these constraints. Constraint wise crop loss estimates provide the rationale for future research thrust. This study has identified a large number of constraints that are being faced by the farmers in these systems. However, this does not mean that all these constraints are major and occur simultaneously. These may occur in the most severe form in any one of the season/year in any one of the sub-regions. The constraints, which are causing major production losses, are discussed below. Table 4 reveals that the nature and magnitude of losses due to various production constraints varies across states and within the states due to fragility and sloppy land.

Average yield loss in rice due to all the constraints is displayed in Table 4 i.e., 2095 kg/ha for Nagaland followed

by Manipur (2082 kg/ha), Meghalaya (1630 kg/ha), Tripura (1258 kg/ha), Mizoram (948 kg/ha) & Sikkim (875 kg/ha). In percentage terms it is about 144, 85, 87 and 95 per cent respectively of average farm level yield. Therefore, there exists a range between 144 to 85 per cent potential to increase the productivity of those selected states in NEH through elimination of the losses.

The loss due to technical constraints ranged from 65 to 74 per cent of the estimated yield gap. Insects and pests are at the top of the list for causing maximum yield loss in case of Meghalaya (458 kg/ha), Manipur (485 kg/ha) and Nagaland (485 kg/ha), whereas in the case of Mizoram it is about 260 kg/ha, for Tripura it is about 214 kg/ha and for Sikkim 202 kg/ha that accounts for as high as 16 to 33 per cent of farm level yield. In Mizoram and Sikkim, insects and diseases are the major factors among all the biotic constraints. The losses caused by stem borer alone accounts for 155 kg/ha for Manipur followed by 114 kg/ha for Nagaland, for Tripura it is about 58 kg/ha while for Meghalaya it is about 22 kg/ha. It was reported that there was a large-scale rice-hispa invasion in Tripura during 2001 and that the yield loss was around 15 to 20 per cent. Other major pests and insects are gundhi bug, gall midge, leaf folder, case worm, armyworm and rats.

Diseases top the list of constraints, causing a maximum yield loss of about 479 kg/ha to 207 kg/ha of those states (Table 4). Among these neck blast and leaf blast cause the most yield loss. In Manipur, the yield loss due to neck blast in about 259 kg/ha, whereas in Nagaland it is 71 kg/ha, and it is as low as 20 kg/ha in Meghalaya and Tripura. The yield loss due to leaf blast ranges from 181 kg/ha to 43 kg/ha among those states. Sheath blight, brown spot and bacterial leaf blight are important diseases of low and mid altitude. In high altitude areas, sheath rot is increasing. Among bacterial diseases, bacterial leaf streak creates a serious problem, contributing to nearly 58 kg/ha to 24 kg/ha yield loss. Severe infestation of weeds, mainly aquatic and non-aquatic weeds during the kharif season, is an important constraint which contributes to the tune of 142 kg/ha to 34 kg/ha to the yield losses. The crop also suffers from poor soil health, as a result of nutrient deficiency, low organic matter content, various forms of soil erosion, and zinc deficiency. Together they cause 299 kg/ha to 78 kg/ha yield loss of rice. It is reported (Roy Choudhury 2003) that in peat soils of Manipur, the incorporation of nitrogenous fertilizers has increased the incidence of blast. In the region low pH very often causes nutrient imbalance. Usually ground at a higher altitude has more organic carbon due to prevailing low temperature. The available phosphorous and potash content of the soil is very poor. Studies (ICAR Complex) show that rainfall coupled with acid soil leads to loss of high amount of nitrogen and phosphorus from rice fields. Since the region falls under rainfed agriculture zone, the water stresses leads to either excess water during growth stage and anthesis stage or deficit water in the vegetative and flowering stage, causing loss of rice yield in the region. Maximum yield loss due to this phenomena comes to 60 kg/ha for Meghalaya and a minimum of 39 kg/ha for Manipur. Low temperature is another constraint for yield losses in this region, as it prevents healthy seed formation. Maximum yield loss for this is about 184 kg/ha in case of Nagaland and 74 kg/ha for Meghalaya. In these two states of NEH region the could mainly hampers the rice productivity during the reproductive stage, whereas in Tripura and Manipur it affects mainly during the vegetative stage of crop growth. Other important constraints are mainly physiological or agronomical issues. Solar radiation is one of the factors that influences rice yield through its

Table 3: Estimated Yields and Yield Gaps in Paddy in NEH Region of India

(Kg/Ha)

Particulars of yields	Manipur	Nagaland	Meghalaya	Mizoram	Sikkim	Tripura
1. Experiment Station Yield*	6775	4578	5343	4933	3745	4555
2. On-farm Experiment Yield*	4524	3551	3505	2475	2310	2587
3. Actual Farm Yield**	2442	1456	1875	1527	1067	1329
4. Yield Gaps***						
a. Yield Gap I	2251	1027	1838	2458	1435	1968
b. Yield Gap II	2082	2095	1630	948	875	1258
c. Yield Gap (I+II)	4333	3122	3468	3406	2310	3226
d. Yield Gap Total (per cent)	177.44	214.42	184.96	223.05	216.49	242.74
e. Yield Gap II (per cent)	85.26	143.89	86.93	62.08	82.00	94.66

Source: *Various experimental results from ICAR Research Complex for NEH – Manipur, Nagaland, Meghalaya. Mizoram, Sikkim & Tripura centre. **Generated by the study/***Self calculated following standardized methodology

Table 4: Estimated per hectare yield (in kg) & income (in Rs.) loss due to biotic and abiotic constraints of rice production in NEH region

Constraints	Manipur	Nagaland	Meghalaya	Mizoram	Sikkim	Tripura
Pest & Insects	484.84	484.58	458	260	202	214.13
Diseases	478.89	495.38	207.2	212	189	265.04
Soil & Nutrient	298.56	77.96	163.2	34	96	213.85
Weeds	141.83	34.05	62.2	55	52	88.66
Water deficit/excess	39.22	56.17	59.80	20	39	47.38
Cold problem	10.20	183.59	73.81	13	30	14.31
Others	17.58	26.68	35.79	24	42	18.39
A. Loss due to technical Constraints (kg/ha)	1470.68 (70.64)	1358.41 (64.84)	1060 (65.03)	618 (65.19)	650 (74.28)	861.76 (68.50)
B. Loss due to Socio-economic (kg/ha)	611.32 (29.36)	736.59 (35.16)	570 (34.97)	330 (34.81)	225 (25.72)	396.24 (31.50)
Total yield loss (kg/ha)	2082	2095	1630	948	875	1258
Gross Income loss (Rs./ha)	11451	11523	8965	5214	4813	6919
Net income loss (Rs./ha)	13582	13659	10628	6184	5512	8202

direct effect on physiological process in grain production. The average sunshine hours in NEH are low during the most sensitive stage of rice. Important among them are poor seed availability and poor quality seeds, improper spacing and delayed sowing, and an imbalance in the use of chemical fertilizers.

The yield losses across states can be summed up in rice production system in NEH region as already shown in Table 4. Value losses from major constraints were aggregated to characterize losses for the rice system. Total gross loss (quantity of yield loss multiplied by its price as quoted by commissioner of Agricultural Price) per hectare from technical constraints in the selected states are in the range of Rs. 11523 to 6919/whereas the net per hectare income loss (quantity of yield loss multiplied by the unit cost of production in the region), ranges between R. 13659/ to Rs. 8202/. The interesting part is that the unit cost of production is more than the unit price of the rice. This is mainly due to the fact that all the required inputs had been supplied from the households, and not a single dose of purchase inputs was used in their rice land. The rationality behind it is that production of rice in the region is guided for the households' food security purpose, not for commercial reasons, which had already pointed out earlier. The annual estimated monetary loss for the region amounted to R. 29486 million, that goes up 103 per cent of yield gap II. The results are important for two reasons. First, a large portion of the yield gap was attributed to technical constraints, demonstrating that solution of these constraints is not trivial. Secondly, loss estimated, when aggregated, was not larger than the yield gap.

It is not surprising that a higher proportion of the production losses can be attributed to socio-economic constraints in rainfed rice production system as compared to irrigated rice-wheat system (Roy and Datta, 1999). This is one of the backward regions in the country with widespread poverty. Resource poor farmers are incapable to use modern farm inputs and thus their farming remains at subsistence level. Poor state of rural infrastructure development is another reason. Moreover farmers in the region are risk avoiders as agriculture in the region is mainly depending on rainfall. The most crucial and guiding force behind adoption of local varieties of rice & for non-adoption of HYV rice varieties is the test and preference of rice consumption habits in the region. The time required for digesting rice is a characteristic that leads to varietal preference. Slow digestibility is preferred as it reduces the frequency as well as the total rice intake. Most farmers indicated a preference for retaining traditional varieties for their home consumption. Test is one of the major quality characteristics determining varietal preferences. Therefore, socio-economic constraints assume a significant role in limiting yield. Relative share of socio-economic constraints to total yield loss is about 35 to 30 per cent of total loss.

Priority research problems

On the basis of estimated loss of value production, the ranking of the top 10 research problem areas in major rainfed rice crops have been suggested in Table 5. Since the ranking of socio-economic constraints is ordinal, it is difficult to compare them with technical constraints. Moreover, these rankings also change across the sub-systems. When the constraints are

Table 5: Ranking of Constraints by Crop in Terms of Value of Production Losses

Ranks	Manipur	Nagaland	Meghalaya	Mizoram	Sikkim	Tripura
I	Neck blast	Leaf blast	Gundhi bug	Gundhi bug	Leaf folder	Non-aquatic weeds
II	Leaf blast	Stem borer	Leaf folder	Ear head bug	Gundhi bug & stem borer	Leaf blast
III	Stem borer	Cold during reproductive stage	Nitrogen deficiency	Stem borer	Brown plant hopper	Gall midge
IV	Nitrogen deficiency	Neck blast	Root aphid	Hispa & gall midge	Gall midge	Potassium deficiency
V	Non-aquatic weeds	Bacterial leaf blight	Non-aquatic weeds	Trips & Termite	Leaf & neck blast	Brown spot
VI	Potassium deficiency	Cold during vegetative stage	Organic matter	Leaf blast	Sheath rot & Brown spot	Organic matter
VII	Case worm	Sheath blight	Leaf blast	Sheath rot	Phosphorus deficiency	Sheath rot
VIII	Rice hispa	Army worm	Cold during vegetative stage	Brown spot	Rice hispa	Nitrogen deficiency
IX	Soil pH	Water stress at anthesis stage	H. Leaf spot	False smut	Non-aquatic weeds	Rice hispa
X	Army worm	False smut	Cold during reproductive stage	Non- aquatic weeds	Water stress at anthesis stage	Water stress at vegetative stage

ranked in terms of their contribution to value production loss, the traditional problems, viz., insects & pests, diseases, water scarcity, soil fertility, weeds etc appear as the major constraints in the rice crop. Insects & pests causing maximum damage in rice production is particularly endemic in the study area. Elimination or partial solution of these priority constraints would have a major impact on rice productivity. Significant losses due to insects & pests in the region demonstrate the acute need for the variety having genetic-resistant traits. Genetic resistance to insects has two-fold advantages: it serves to increase yields and reduces the dependency of the farmers on insecticides, thereby addressing environmental concerns. Biotechnology embraces a range of technical possibilities, the future potential of which is still being hypothesized.

Germ plasm that has got resistance to diseases, needs to be identified and introduced. Chemical and cultural controls need to be maintained, and the search for genetic resistance variety should be continued. Invariably the quality of the produce is found to be inferior in rice as the grains are not fully developed or the colours are not attractive. Breeding for biotic stress has been reoriented with the objective of developing multiple pest resistance and durable resistance. Towards this goal, a marker aided selection is the new approach being adopted.

Socio-economic constraints are needed to be addressed through research and policy intervention, which had a potentiality to enhance the productivity from between 30 to 35 per cent from existing production level. As regards to socio-economic constraints, the topmost problems are related to non-availability of rice variety which can accommodate the test and preference of the tribal farmers in the region, inadequate and untimely supply of critical inputs (like seed-fertilizer-irrigation-power & credit), unaffordable prices of those inputs, risk in production, price, and poor rural infrastructure. The seed rate being high, the cost of improved seed remains the biggest bottleneck in increasing rice production in this region. Non-availability of high quality seeds at an affordable price and selling of substandard seeds at a high price also put a barrier in rice cultivation as poor farmers cannot purchase it and they keep on growing whatever seed material possess. Some farmers even if they want to purchase high quality seeds do not get them at the time of sowing. The farmer's access to cash is frustrated by financial institutions, which adopt complicated procedures for granting and recovering agricultural loans. Poor credit facilities to small and marginal farmers force them to adopt traditional agriculture. Marketing of rice is highly unregulated resulting in large fluctuation in prices, which discourages to the farmers. Since everyone grows the same crop in the same season they become ready for sale at the same time. Inadequate and inefficient procurement system coupled with predominance of local traders, reduces the profitability and the farmers do not get their due share despite a high price paid by the consumers.

The poor storage and transport facilities add to this problem. Incidence of insect pests and diseases are

very high in the region. Numerous pesticides have been recommended but due to the high cost of such materials and their non-availability in remote villages, the farmers apply pesticides at a sub-optimal level. Lack of awareness about improved technologies and transfer of technology from research station to the farmer's field had been probably the major hurdle in achieving potential yield in this region.

At the same time policies are also needed to encourage the use of potential biological substitutes to the agro-chemicals. The concept of vermicompost may alleviate the position to some extent at on-farm production level. There is also a need for greater thrust on promotion of technologies which could minimize the use of costly inputs and result in natural resource conservation such as IPM and INM, that would be the key for an evergreen revolution. The research findings on IPM and INM technologies are still to be translated into a reality for want of required policy support. Some mechanism to reduce losses due to weeds in clearly necessary. Although many conventional methods are available, they are not successful enough to prevent huge production loss. Integrated weed management techniques will have to be evolved to solve this problem in existing areas and to limit its spread in new areas. To ensure the returns in the fragile upland ecosystem, intercropping of rice with soybean or groundnut may be suggested.

Equally important will be timely supply of quality inputs, especially in remote hilly areas. This requires revamping the entire infrastructure for an effective input supply system. Finally, development agencies and private sector should ensure that the critical inputs like quality seeds of recommended rice cultivars, pesticides, fertilizers and credit necessary for productive rainfed rice farming, are timely available.

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□

The most pathetic person in the world is someone who has sight but has no vision.

– Helen Keller

Feature

Impact of Technological Change in Mulberry Cocoon Production

P. Kumaresan, Sumanta Behera & R.G. Geetha Devi

This study was conducted to examine the nature of technological changes in cocoon production through the measurement of productivity differences between new and conventional sericulture technologies.

P. Kumaresan and R.G. Geetha Devi are with Central Sericultural Research and Training Institute, Sriramapura, Mysore-570008 and Sumanta Behera is with the Dept. of Textiles and Handloom, Orissa.

Silk, which spells luxury, elegance, class and comfort, is acclaimed as the queen of textiles. Silk is reeled out of the cocoons of the silkworm produced by the farmers and used in weaving of the dream fabric. In India, silk production is regarded as an important tool for the economic development of the country, as it is a labour intensive and high income generating industry that churns out value added products of economic importance.

India is the second largest producer of mulberry raw silk, with an annual production around 14000 M.T. Although the area under mulberry has remained virtually constant over a decade, there was constant growth in raw silk production in the country, which can be attributed to increase in the yield. The silk productivity has increased from 19.50 Kg/Ha during 1971-72 to 68.26 Kg/Ha during 2001-02. Though silk production achieved a spectacular growth in India, still most of the production is a cross between multivoltine and bivoltine breeds, which are inferior in quality and productivity compared to bivoltine hybrids.

Many attempts have been made since the Fifth five-year plan to improve the production of biovoltine silk in the country. However, owing to various reasons, the bivoltine silk production of biovoltine silk in the country. However, owing to various reasons, the bivoltine silk production has not crossed even 500 M.T. per annum. Recently, the new bivoltine hybrid namely, CSR2 Û CSR4 is becoming popular with the sericulturists. The studies conducted by Lakshmanan et al. (2000), Srinivasa et al. (2001), Kumaresan et al. (2002) and Hiriyanna et al. (2002) revealed that the yield levels of CSR hybrid were significantly higher than that of the existing cross breed. Consequently, the concern of the policy makers is about knowing the potentialities created by the new bivoltine sericulture technologies and their implications in sericulture development policies for achieving the socio-economic goals of rural farmers, and meeting the country's growing demand for quality silk.

Normally, introduction of new technology is considered to be more profitable and helpful in generating direct employment opportunities at the farm level. But the higher yield obtained by the farmers due to the adoption of a new technology is not necessarily a technological improvement over existing technology, but may be due to increase in input use. In this context, a study is proposed to examine the nature of technological changes in cocoon production through the measurement of productivity differences between new bivoltine sericulture technologies and the conventional multivoltine sericulture technologies and analyze the constituent sources of such differences.

Methodology

The study was conducted in Mandya district, as it is the largest producer of bivoltine cocoons in Karnataka. Srirangapatana and Pandavapura taluks were purposively selected in Mandya district based on the area under irrigated mulberry. Initially, the list of sericultural villages and in each village, the names of CSR hybrid rearers and cross breed cocoon producers were obtained from local Technical Service Centres of the Department of Sericulture, Karnataka. In both the taluks, 7 villages were selected at random and in each village, 5-6 cross breed rearers and another 5-6 CSR hybrid rearers were selected at random for the collection of data. Thus, 38 CSR hybrid and 37 cross breed rearers were selected for data collection in Srirangapatana taluk and 38 cross breed and 37 CSR hybrid farmers formed the sample in Pandavapura taluk. The total sample size constituted 75 CSR hybrid and 75 cross breed rearers. The data on various aspects of cocoon production on farmers' field were collected with the support of pretested interview schedule during the year 2002-03.

Analytical framework

The Cobb-Douglas production model was chosen over the linear form based on the goodness of fit to study the input-output relationship of each variable input in cocoon production. Here, the quantum of cocoon production per acre per year was considered as the dependent variable and regressed with the factors of cocoon production. The function employed in the study can be expressed as:

$$Y = AX_1^{b1} X_2^{b2} ..... X_5^{b5} \mu \quad ...(1)$$

Where

Y = Cocoon production (kg/acre/year)

X_1 = Farmyard manure (MT/acre/year)

X_2 = Cost of fertilizers (Rs./acre/year)

X_3 = Labour (Man days/acre/year)

X_4 = Depreciation on rearing house and rearing appliances (Rs./acre)

X_5 = Cocoon-feed ratio.

A = Intercept

$b_i S$ = Regression coefficients (elasticity coefficients)

μ = Random term independently distributed with zero mean and finite variance

The parameters of the function 'A' and b_i S were estimated separately for both cross breed and CSR hybrid using least square regression analysis by converting the functions into log-linear forms. The equations specified for cross breed and CSR hybrid are respectively, as

$$\text{Ln } Y_1 = \text{Ln } A_1 + b_{11} \text{Ln } X_{11} + b_{21} \text{ Ln } X_{21} + b_{31} \text{ Ln } X_{31} + + b_{41} \text{ Ln } X_{41} + b_{51} \text{ Ln } X_{51} + \mu ..... \quad ...(2)$$

$$\text{Ln } Y_2 = \text{Ln } A_2 + b_{12} \text{ Ln } X_{12} + b_{22} \text{ Ln } X_{22} + b_{32} \text{ Ln } X_{32} + + b_{42} \text{ Ln } X_{42} + b_{52} \text{ Ln } X_{52} + \mu ..... \quad ...(3)$$

In order to study the technological difference between CSR hybrid and cross breed, the model followed by Bisalaiah (1977) was adopted. Chow's F test (Chow, 1960) was employed to identify whether the parameters governing the production relations in the cross breeds are different from those of CSR hybrid. Taking the differences between equations (2) and (3), adding some terms and subtracting some terms, yield decomposition models can be written for cross breed and CSR hybrid as follows:

$$\begin{aligned}\text{Ln } Y_2 - \text{Ln } Y_1 = {} & (\text{Ln } A_2 - \text{Ln} A_1) + (b_{12} \text{ Ln } X_{12} \\ & - b_{11} \text{ Ln } X_{11} + b_{12} \text{ Ln } X_{11} - b_{12} \text{ Ln } X_{11}) + (b_{22} \text{ Ln } X_{22} \\ & - b_{21} \text{ Ln } X_{21} + b_{22} \text{ Ln } X_{21} - b_{22} \text{ Ln } X_{21}) + (b_{32} \text{ Ln } X_{32} \\ & - b_{31} \text{ Ln } X_{31} + b_{32} \text{ Ln } X_{31} - b_{32} \text{ Ln } X_{31}) + (b_{42} \text{ Ln } X_{42} \\ & - b_{41} \text{ Ln } X_{41} + b_{42} \text{ Ln } X_{41} - b_{42} \text{ Ln } X_{41}) + (b_{52} \text{ Ln } X_{52} \\ & - b_{51} \text{ Ln } X_{51} + b_{52} \text{ Ln } X_{51} - b_{52} \text{ Ln } X_{51}) + (\mu_3 - \mu_1)\end{aligned} \quad ...(4)$$

Rearranging the terms,

$$\begin{aligned}\text{Ln } Y_2 - \text{Ln } Y_1 = {} & (\text{Ln } A_2 - \text{Ln } A_1) + [(b_{12} - b_{11}) \text{ Ln } X_{11} \\ & + (b_{22} - b_{21}) \text{ Ln } X_{21} + (b_{32} - b_{31}) \text{ Ln } X_{31} \\ & + (b_{42} - b_{41}) \text{ Ln } X_{41} + (b_{52} - b_{51}) \text{ Ln } X_{51}] \\ & + [b_{12} (\text{Ln } X_{12} - \text{Ln } X_{11}) + b_{22} (\text{Ln } X_{22} - \text{Ln } X_{21}) \\ & + b_{32} (\text{Ln } X_{32} - \text{Ln } X_{31}) + b_{42} (\text{Ln } X_{42} - \text{Ln } X_{41}) \\ & + b_{52} (\text{Ln } X_{52} - \text{Ln } X_{51})] + (\mu_3 - \mu_1)\end{aligned} \quad ...(5)$$

By using the logarithmic rule, the equation (5) can also be written as

$$\begin{aligned}\text{Ln } Y_2/Y_1 = {} & [\text{Ln } (A_2/A_1)] + [(b_{12} - b_{11}) \text{ Ln } X_{11} \\ & + (b_{22} - b_{21}) \text{ Ln } X_{21} + (b_{32} - b_{31}) \text{ Ln } X_{31} \\ & + (b_{42} - b_{41}) \text{ Ln } X_{41} + (b_{52} - b_{51}) \text{ Ln } X_{51}] \\ & + [\{b_{12} \text{ Ln } (X_{12}/X_{11})\} + \{b_{22} \text{ Ln } (X_{22}/X_{21})\} \\ & + \{b_{32} \text{ Ln } (X_{32}/X_{31})\} + \{b_{42} \text{ Ln } (X_{42}/X_{41})\} \\ & + \{b_{52} \text{ Ln } (X_{52}/X_{51})\}] + (\mu_3 - \mu_1) \qquad ...(6)\end{aligned}$$

The resultant equation (6) decomposes the total difference in cocoon production between old and new cocoon production technologies (on left-hand side of equation) into

1. Neutral technological change (First bracketed expression on right hand side)
2. Non-neutral technological change (Second bracketed expression on right hand side)
3. Change in the level of inputs (Third bracketed expression on right hand side)

On the right hand side of the equation, the first two bracketed expressions, summed up, measure the joint contribution of the component of technology.

The first bracketed expression on the right hand side is a measure of percentage change in output due to shift in scale parameters (A) of the production function. The second bracketed expression is the sum of the arithmetic changes in output elasticities, each weighted by the logarithm of volume of that input used under old technology, as a measure of change in output due to shifts in slope parameters (output elasticities) of the production function.

The third bracketed expression is the sum of the logarithm of the ratio of input used in new technology to input used in old technology, each weighted by the output elasticity of that input under new technology. This expression is a measure of change in output due to changes in farmyard manure, fertilizers, labour, capital used and quantum of feeding, given the output elasticities of these inputs under new production technology. The last bracketed expression is related to the difference in error terms.

Results and Discussion

Decomposition analysis needs values of production function estimates and geometric levels of inputs and outputs.

Input-output relationship in cocoon production

In order to assess the efficiency of resources used in cocoon production, a Cobb-Douglas type of production function was fitted separately for cross breed and CSR hybrid by considering farmyard manure, fertilizer costs, labour, capital expenditure on rearing house and appliances and cocoon-feed ratio as independent variables and quantum of cocoon production as dependent variables. The estimates of the fitted regression equations are presented in Table 1.

Table 1: Production function estimates for cocoon production

Sl. No.	Variables	Regression coefficient		
		CSR Hybrid (N = 70)	Cross breed (N = 70)	Pooled (N = 70)
1.	Constant	6.4350	6.2810	6.048
2.	Farmyard manure (MT/acre/year)	0.1290** (0.0300)	0.0474 (0.0500)	0.0917** (0.0250)
3.	Fertilizers (Rs./acre/year)	0.3400** (0.0980)	0.3240** (0.0510)	0.3730** (0.039)
4.	Labour (Mandays/acre/year)	0.0262 (0.0210)	0.0875** (0.0320)	0.0484** (0.0170)
5.	Depreciation on rearing house and equipments (Rs./acre/year)	-0.0208* (0.0100)	-0.0296* (0.0170)	-0.02291** (0.0080)
6.	Cocoon feed ratio	0.9390** (0.1240)	0.9020** (0.1300)	0.9280** (0.1180)
	R^2	0.8790	0.858	0.869

Note: *Significant at 5% level, **Significant at 1% level

The coefficient of multiple determination (R^2) was worked out to 0.879, 0.858, 0.869 for CSR hybrid, cross breed and pooled data respectively implying that 87.90 per cent, 85.80 per cent and 86.90 per cent of variation in the cocoon production could be explained by the variables included in the respective function. This indicated that the selected form of the production function was the best fit.

The values of the regression coefficient (elasticity of production) were less than one for all the inputs considered in the production functions. This shows that each input included in the production function followed diminishing marginal productivity. The coefficients of farmyard manure, fertilizer cost and cocoon-feed ratio were positive and statistically significant for CSR hybrid. This implies that one per cent increase in these resources over the geometric mean levels would contribute respective percentage increase in cocoon production. Hence, it may be inferred the farmyard manure, fertilizer and cocoon feed ratio were the important variables, which significantly influenced the CSR hybrid cocoon

production. The regression coefficient of depreciation on rearing house and equipment was statistically significant but had negative sign, which is contrary to the expected positive sign. This may be due to inefficient use of facilities by the CSR hybrid rearers for the production of cocoon. The production coefficient of human labour had positive sign as expected a priori, but statistically was not significant.

In the production function fitted for cross breed, the production elasticity of fertilizer expenditure, human labour and cocoon-feed ratio were positive and significant. The output elasticity of farmyard manure was positive but statistically not significant. The regression coefficient of depreciation on rearing house and equipments was inversely related to cross breed cocoon production as in the case of CSR hybrid against the expectation.

Chow's test was conducted to examine the structural difference between the two technologies, namely CSR hybrid and cross breed. The results of this analysis indicated that the F value (44.78) was statistically significant at one per cent level. Thus, proving that the two production functions defined for cocoon production differed significantly. These differences were due to changes in the slope as well as intercept differences. This result offered the required justification for decomposing the production functions of cross breed and CSR hybrid into its constituent sources, that is technological change and changes in the level of inputs, while shifting from old technology of cross breed cocoon production to new cocoon production technology of CSR hybrid.

Table 2: Geometric mean levels of inputs and output of sample farmers

Sl.No.	Variables	Mean value	
		CSR hybrid	Cross breed
1.	Farmyard manure (MT/acre/year)	6.97	6.39
2.	Fertilizers (Rs./acre/year)	2394.86	1772.95
3.	Labour (mandays/acre/year)	293.49	336.65
4.	Depreciation on rearing house and equipments (Rs./acre/year)	6777.33	5351.74
5.	Cocoon feed ratio	0.039	0.028
6.	Cocoon production (Kg/acre/year)	487.09	348.96

The geometric mean levels of input use were estimated independently for CSR hybrid and cross breed and the results are presented in Table 2. With regard to inputs, the cocoon feed ratio was 39.29 per cent more for CSR hybrid compared to that of cross breed. This means that the feed (mulberry leaf) is efficiently utilized for the conversion of cocoons in case of CSR hybrid compared to that of cross breed. Though CSR hybrid consume more mulberry leaf than cross breed, as the productivity is more in case of CSR hybrid, the cocoon feed ratio was found to be more with CSR hybrid compared to cross breed. The labour use was 12.82 per cent less for the CSR hybrid rearers compared to their counterparts as CSR hybrid was preferably reared in shoot rearing method which is a labour saving technology, when the traditional farmers rear silkworm using the method of tray/shelf rearing method. The shoot rearing method is preferred for CSR hybrid over the traditional method, as it is more hygienic with less physical handling of silkworms.

The capital investment on rearing house and equipment was found to be more for the CSR hybrid farmers compared to that of the cross breed rearers, as CSR hybrid rearing was mostly taken up by the farmers who had separate rearing house and adequate rearing facilities due to more susceptibility to diseases. With respect to usage of plant nutrients, there was not much difference with respect of usage of farmyard manure between the two groups, but CSR hybrid farmers spent more money on fertilizers compared to cross breed rearers. Also, the productivity level of CSR hybrid was significantly higher than that of cross breeds. The productivity difference was found to be 34.50 per cent.

Decomposition of output gain due to technological change in cocoon production

The output gain in cocoon production due to the shift in the rearing technology from cross breed to CSR hybrid was decomposed to study sources contributing to yield gain. The results of decomposition analysis are presented in Table 3. There is a slight discrepancy between observed and estimated gains in productivity between cross breed and CSR hybrid. This may be attributed to the random term, which among others, accounts for variable management input, which could not be included in the model.

The total gain in cocoon production due to the shift from cross breed to bivoltine hybrid was found to be 35.22 per cent, which was mainly contributed due to the difference in the levels of input use. The contribution of technological change to the yield gain was 1.12 per cent, which implies that the output of the cocoon production could not be increased with the same levels of inputs used under the old technology. Among the components of technological change, the contribution of neutral technological change in total productivity was

estimated to be 15.40 per cent. This indicates that mere adoption of CSR hybrid in place of cross breeds would bring an upward shift in the cocoon yield, but this gain was offset by the negative contribution of the non-neutral technologies to the yield gains. The negative non-neutral technologies implied that there was decrease in efficiency of inputs used with the adoption of new technology, as the farmers were not able to adjust to the new requirements of bivoltive silkworm rearing technology. It was observed in the survey that most of the farmers did not continuously rear the bivoltine hybrids. As the farmers rear bivoltine hybrid and cross breed interchangeably, they were not adjusting to the new requirement when they reared bivoltine.

Table 3: Decomposition of productivity gain in cocoon production

Sl.No.	Sources of change	Percentage contribution
A.	Total observed productivity gain	34.49
B.	Productivity gain due to technological change	
1.	Neutral technological change	15.40
2.	Non-neutral technological change	–14.28
	Total productivity gain due to technological change	1.12
C.	Productivity gain due to input use	
1.	Farmyard manure	1.13
2.	Fertilizers	10.22
3.	Labour	–0.36
4.	Depreciation on rearing house and equipments	–0.49
5.	Cocoon feed ratio	23.60
	Total productivity gain due to input use	34.10
	Total estimated productivity gain	35.22

With regard to the difference in the level of input use, cocoon- feed ratio contributed to 23.60 per cent gain in the cocoon production of the total 34.10 per cent gain due to input use. The silkworm requires nutritive food to produce cocoons with good built and quality. As most of the CSR hybrid rearers possessed V1 mulberry variety, which is rich in nutrients compared to other mulberry varieties, the feed conversion was good in CSR hybrid. The contribution of fertilizers to the production gap was 10.22 per cent. The changes in the level of use of farmyard manure did not contribute significantly to the yield gains in CSR hybrid. As it is evident from the production function analysis (Table 1), rearing house and equipments were not utilized properly. Hence, it caused a negative contribution to total productivity. Similarly, the contribution of labour was negative towards the improvement in productivity. The total contribution of the differences in levels of input use to the productivity gain was 34.10 per cent. This indicates that the productivity of the cross breed can be increased by 34 per cent if the input use levels on these farms could be increased to the same level of CSR hybrid.

It can be inferred from the decomposition analysis that the sericulturists were not able to consolidate the technology gain due to the introduction of new technology. The yield gain was obtained only due to the adjustment made in the input, especially in the feed.

Summary and Conclusion

The study was conducted to examine the nature of technological changes in cocoon production through the measurement of productivity differences between new bivoltine sericulture technologies and the conventional multivoltine sericulture technologies and analyze the constituent sources of such differences. The production function analysis indicated that farmyard manure, fertilizer and cocoon feed ratio were the important variables that significantly influenced the CSR hybrid cocoon production. Fertilizer, human labour and cocoon feed ratio had significant and positive relationships with cross breed cocoon production. The regression coefficient of depreciation on rearing building and equipment was significant, but had a negative sign for the production functions fitted for CSR hybrid and cross breed. This was due to inefficient use of fixed assets for the silkworm rearing.

The total gain in cocoon production due to the shift from cross breed to CSR hybrid was found to be 35.22 per cent, which was mainly due to the difference in the levels of input use. The results indicated that adoption of CSR hybrids in place of cross breeds would bring an upward shift in the cocoon yield. The positive contribution of neutral technological change (15.40%) was offset by the negative contribution of non-neutral technological change (14.28%), resulting in meagre yield gain due to technological change. The yield gain due to changes in input use was significant with 34.10 per cent. Among the differences in the level of input use, cocoon feed ratio contributed to 23.60 per cent gain in the cocoon production of the total yield gain.

The analysis of decomposition of output gain indicated that the farmers were not able to consolidate the gains obtained from the technological change from cross breed rearing to bivoltine silkworm rearing, as they were not able to adjust to the new requirements of bivoltine silkworm rearing. Hence, the extension agen-

cies should make efforts to teach the farmers about the difference between the bivoltine and cross breed silkworm rearing. This was emphasized by Kawakami (1999) based on the experience gained in JICA assisted Promotion of Popularizing the Practical Bivoltine Sericulture Technology Project (PPPBST) implemented in Karnataka, Andhra Pradesh and Tamil Nadu.

The decomposition analysis also revealed that the yield gain in CSR hybrid over cross breed was mainly due to the feed. Hence, the effort may be taken to popularize the bivoltine hybrids only with the farmers having good irrigation facilities, high yielding mulberry varieties and required infrastructure facilities for silkworm rearing. The farmers' specific approach for the bivoltine sericulture may yield rich dividends in bivoltine sericulture development.

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Simplicity means products of the best quality displaying essential elements, but without additional ornamentation or clutter.

– Peggy Fritzsche

News & Notes

Management Education in India: Recommendations for actions by S.L. Rao

This paper examines several ways in which B-Schools in India can improve, including networking with better schools, using modern communications technology and finding live management experiences.

Purpose of Management Education

Management education must develop skills in the students that would enable them to take decisions on the basis of limited information, in situations marked by uncertainties, relate their studies to the needs of society, inculcate value-based learning and ethics, and lay the conceptual foundations that could be applied in any similar situation.

These skills must be applicable to any situation in which decisions have to be taken for achieving the objectives of the organisation.

Specialization

1. As the world globalizes, situations become more complex and uncertain. Specialization has become more relevant than in the past when movement between sectors and functions was easier. B-schools can run stand alone courses for a sector or function, or integrated courses, but general management has to be part of both.
2. Specialization function could be achieved through electives; guest faculty could be used in smaller schools, where adequate expertise may not exist.
3. By sectors specific to particular industry sectors (for example, pharmaceuticals, construction, etc., or social sectors like health, rural development, education, arts management, etc) specialization could be through a branching out in the second term to focus on teaching to that sector. However, preparatory work is required to comprehensively design sector programmes in consultation with sector experts.
4. Such specialized sector programmes are perhaps better addressed through an integrated sector-specific programme in management starting from the first year itself and fully focused on that sector.
5. Management education must customise for other areas of application as well: for example, agricultural services, infrastructure management, contract research, high technology entrepreneurship, hospital management, NGO management and ITES.
6. Issues to be addressed in designing customised programmes are curricula customisation, specific material development and faculty specialisation.

Exposure to "Bharat"

1. Practicing managers talk of their having had to de-learn what they learnt at B-schools. The process of learning afresh in industry entails understanding the realities of the business and the country. This also demands an understanding of the rural, small town and "desi" India.
2. Along with this is the question of employability of management graduates in non-government organisations, art institutions, agricultural product companies, cooperatives, etc, if such specialized courses were offered. Students may not opt for such courses because they are seen as being less remunerative. The remuneration on employment must be high enough to compensate for

the high fees charged for any management education.

3. Reputed management schools find that programmes not aimed at industry when offered along with other programmes aimed at industry that earn more for the B-school, are not cost-effective since they divert limited faculty time.
4. However, there is definite scope for programmes focused on these less 'remunerative' sectors. This is because these sectors have both not-for-profit and for-profit segments.
5. Several B-schools have had experiences of student exposure to "Bharat". These need to be collected as examples for others to follow.

Governance of Management Education

1. The AICTE should not have jurisdiction over management education but should concentrate on technical courses. Management Education must come under a separate statutorily recognized Board.
2. Self-regulation is the best regulation. There must be a body by stature that will monitor the institutes (the word here is used to include university departments, private and government institutions). Frequent inspections by regulators/ facilitators are essential particularly for institutes that need hand holding.
3. Whether it is a self-regulating body or is appointed by the government, the regulatory body must have a board with up to nine members including a chairman. Members must have fixed terms – of up to six years and age 75. The members must be people of eminence, recognised for their integrity. The board should have the powers to de-recognise poor quality B-schools and should be insulated from political interference.
4. The board must be similar to SEBI or CERC or TRAI with the regulators being truly independent of any external influences.
5. Financing for the functioning of such a regulatory body would be through fees paid by all B-schools (including universities), like chartered accountancy firms do to the Institute of Chartered Accountants. The regulatory body for management education could be authorised by law to levy a fee from all management schools. Moving away from government dependence for funding will make the body truly independent.
6. All bodies giving certificates/diplomas/training in management must come under the purview of this body. It must be considered whether purely training institutes (not part of a company training establishment) should also come under its purview.
7. The regulator must have enough teeth and should be vested with legislative, executive and quasi-judicial powers over aspects such as funds, penal authorities and, importantly, the power to derecognise.
8. Total transparency in the functioning of the regulatory body is vital (i.e., all documents are in the public domain, all decisions are publicised and reasoned, opportunity is given to all to express their views).
9. A search committee with a fixed term and consisting of eminent academics, industrialists and managers should appoint the members of the regulatory body.
10. The regulatory body would have members from among academics, top professional managers, industry experts, consultants, figures from leading national industry associations, AIMA, leading businesses (including small and medium enterprises) and social organisations, apart from faculty from the best B-schools.
11. However, the body should have a maximum of five full-time and four part-time members, i.e. a total of nine members.
12. The regulatory body would set up as independent agency for accreditation. The criteria for accreditation would have to be drawn up based on Indian experiences.
13. Accreditation and recognition must be two separate processes and be a continuous affair.
14. Recognition of courses should be a separate process from that of recognition of institutions as a whole.
15. University affiliation should not be mandatory for management education. It adds one more layer of governance, allows the award of a degree but does not add to the quality of the education.

Role of Regulation

1. There must be only one regulatory body for management education irrespective of whether the institutions are government-controlled, university departments, NGOs or private.
2. There can be no objection to B-schools produc-

ing a surplus on operations subject to quality standards and expenditure norms laid down by the regulatory body are met.

Governance of B-schools

1. Government must distance itself and not pack the boards of IIMs and other government created institutions with its nominees and officials.
2. University departments of management education must also have independent governance with outside expert representations.
3. Similarly, all private institutions must have independent governance.
4. Provisions applicable to company boards under the Indian Companies Act and clause 49 of the SEBI listing agreement must apply to all management schools.
5. All institutions must manage their finances so that they provide adequate (percentages to be laid down by the regulator) funding for scholarships, research, case collection and publications.
6. There must be transparency in the accounts of all B-schools, in their governance, and their records in terms of faculty quality. They must be made public knowledge, easily accessible to all, through annual reports with audited accounts published each year within a short period (to be laid down) from the closing of the year.

Autonomy of Business Schools

Autonomy must include the power of the management and the faculty to select faculty, decide on pedagogy and the courses to be taught, compensation to faculty, fees to be charged (provided the expenditures provide adequate amounts for scholarships, research, case writing, faculty development, etc). Batch sizes must also be a decision left to the institutions. Of course, all will be public knowledge and the regulatory body will monitor and the ratings agency will set out the quality achieved. Admissions will be to pre-announced norms.

Role of Boards of B-schools

There must be governing boards for every B-school whether run privately or by universities. There must be faculty representation on the board. There must be independent members who have no connection with the promoters and who do not benefit in any way other than, possibly, sitting fees and expenses for travel. Finances must be transparent and published after audit every year, in time. Delays must result in penalties. Expenditure and income should be audited and accounting policies set by an audit committee consisting of independent members.

Ratings of B-Schools

All schools must be rated and ranked each year. There must be compulsory 100 per cent participation of all B-schools in these rating studies. There should be one rating done by an independent and non-profit agency set up by the regulatory body. Any other ratings by private bodies could continue.

Strong Schools to Uplift Weak Ones

1. As a transitory measure, since so many sub-standard B-schools have been recognised, and to help improve their standards, strong schools might each be given the task of overseeing a few weak ones and to uplift them.
2. Consortia of B-schools in proximate geographical areas could help to stretch resources in combination and make fuller use of them. These resources could be library, computers, playgrounds, surplus hostel space, faculty, faculty training, participation in management development programmes, case collection and rural development projects.

Resources

Government Funding

1. Business schools should not receive government funding especially to meet current expenses since they can earn the required funds through fees and consultancy. Even the remotest B-school, of low quality, is able to attract students who are willing to pay.
2. Government today has the final say in the case of IIMs, on appointments of directors and the board, salary limits, new courses. This is also true of university administrations. Not taking government money might avoid/minimise interferences in these institutions.
3. Most successful global business schools have some combination of the following and there is no reason why Indian B-schools cannot do the same.

   a. A large corpus and endowments

   b. Earnings from services to government and companies

c. Corporate sponsorship of chairs and scholarships and

d. Fairly high student fees.

Corporate Financial Support

Corporate support in forms other than financial – such as facilitating the development of useful projects – may be more beneficial than corpus funding. There can be no hard and fast rule since there are companies that have sponsored Chairs and whole programmes. But the funding must be unconditional. Getting corporate support requires close interaction with companies and their managers, with visiting speakers and guest faculty, project assignments, summer placements, management development programmes and consultancy assignments.

Fuller Utilisation of Resources

1. Resources such as library, computers, play facilities, etc., must be fully utilized.
2. Networking between schools can make a 'real' library almost redundant.

Consultancy

1. All B-schools must have a proportion of faculty as visiting faculty from industry who can also help the purely academic faculty to offer more practical consulting advice.
2. AICTE, or its successor, could have central and regional libraries, conference centres, and placement cells that the member institutions could draw upon.

Financial Commitments on B-Schools

1. All B-schools must be required by the regulator to earmark a minimum proportion (to be specified) of their gross incomes for
   a. Scholarships
   b. Outreach programmes
      i. Research and case writing
      ii. Pedagogic innovation
      iii. Faculty development
      iv. Incentives to faculty for academic contributions.
2. Management education must ensure a good return on investment after ploughing back funds to improve the school. Profit should not be at the cost of the quality of education.

Technology

1. Technology can only supplement the learning derived from classroom interactions between students and with faculty.
2. Technology through video-conferences, satellite television linked classrooms, internet that rooms, e-blackboard, etc. can supplement teaching to a considerable extent. Information on these must be disseminated among B-schools and their use encouraged by the regulatory body.
3. Technology can be used to expose faculty and students in weak schools to better faculty in strong schools e.g., through V-sat, video-conference facilities, etc.

Content

Generalisation VS Specialization

1. Specialization is essential and could be considered through electives towards the end of the course. Generalisation gives conceptual understanding and should constitute the core courses.
2. Specialization has now widened to include emerging sectors like retail, e-business, telecom and power, retail, insurance, telecom, HRD, e-business, family business, services, healthcare, hospitality, biotech and banking.
3. Specialized courses that are sector specific from the outset could develop people who are focused on selected sectors.
4. Specialization through electives will create more generalist managers who could more easily cross over into more than one sector.
5. Working managers might benefit more from specialized sector exposure. Freshers must get a core of generalist learning.

Case Study Method

1. While the case method has limitations in providing experiential learning, well-written cases with good teaching notes provide management learning that bases itself on real life situations.
2. Financial incentives should be available for case writing. Faculty career progression could be made partly dependent on cases written and published.
3. Training and development of faculty to use and write cases is essential. (IIM Kozhikode under-

takes case analysis sessions, for example, for faculty).

4. Adequate funding for travel, reduced workload on other activities, research assistance and technology resources are essential.
5. Cases must have depth and well defined teaching objectives.
6. AIMA is particularly well placed to conduct case pedagogy intensive workshops for faculty and to run a National Case Bank. AIMA must take on this task.
7. Stories with well-selected material could be useful teaching methods and might be experimented with especially to set contexts.

Management and the Policy Environment

1. Policy studies that help to learn skills for predicting what the environment will be like, so as to find opportunities and anticipate threats to the company that might arise in the future, need to be taught.
2. Scenario building to develop alternative visions of the future and the directions in which various parameters might move within them is a subject that would help management students in their future careers. It calls for an inter-disciplinary approach, an ability to visualise lateral linkages and is a useful exercise in futurology.

Summer Training

The present programme of industry exposure to students through summer placements does not serve much purpose because.

1. It does not stimulate interface between industry and academia due to the inexperience of most management faculty with industry.
2. For adequate learning, a faculty guide must regularly visit the industry where the student is undergoing placement ad closely supervise his work and his learning from it.
3. For this to happen, faculty need to be given the time required.
4. There must also be a 'guide' or mentor in the industry for the student on summer placement.
5. For this to happen the industry must have had other experiences with the business school through consultancy ad management development programmes. This must be actively pursued by the B- school.
6. The present period of summer placement is too short for the student to learn much or for the industry to give much attention to student.
7. The Oxford model of students who return to their work place after a period of education and faculty interact with them in the work place as well, is worth experimenting with.
8. Summer training guidance cannot be left to part-time 'guest' faculty.
9. Summer projects need not be only in corporate environments and could be in non-traditional areas such as NGOs working in a variety of fields or managing rural development projects.
10. The mindset of many management students that summer placements are a prelude to permanent employment and their consequent preference for attachment to successful companies must change if useful summer placements are to become possible for all students. Faculty must actively change this mindset.
11. Experiential learning could be got even within the Institute when students perform allotted tasks relating to administration of the institute the programme itself (second year students as teaching assistants for example), assisting institute consulting projects, etc.
12. The majority of business schools are probably small in size, with few and poorly trained faculty, and located n many cases in small towns where there are few organised large companies. They have, therefore, to think of ways in which to give students field experience in management.

Strengthening Summer Training

a. 6-8 weeks is inadequate for summer projects.
b. Like HLL sends its management trainees after recruitment to work in rural locations, business schools might send students for summer placement to NGOs and other such organisations.
c. This exposure to social projects must be mandatory in some form in all B-schools.

Teaching Entrepreneurial Skills

Management education appears more focused on the elimination of risk than on risk-taking. Every effort must be made to teach students about risk-assessment and risk-taking.

Interactions with small but successful entrepreneurs are educative and sometimes most inspiring.

Shifting the focus of management education away from creating managers to becoming entrepreneurs cannot be achieved in a management education programme. But management education can provide an exposure to entrepreneurship and risk taking.

While entrepreneurial skills are difficult to teach, business schools could encourage exposure to entrepreneurship. Case studies, seminars and special sessions can showcase examples of successful entrepreneurship including those in non-conventional sectors such as grameen banks, self-help groups, cooperatives etc.

Most students of management have usually experienced repeated success in their past school and college careers. Perhaps they could be taught be taught to experience and manage failure and so anticipate it and manage it, an essential quality for entrepreneurship. This could be done through a variety of ways – compulsory acting, adventure sports, etc.

A model that could be evaluated and perhaps copied by others is from IIM Lucknow: A course in "New Venture Planning" gives perspectives from different functional areas like marketing, finance, operations strategy and also preparation of business plans.

IIM Bangalore offers four electives in this area but does not expose students to the Nadathur S Raghavan Centre for Entrepreneurial Learning that has a state-of-the-art incubator to help entrepreneurs launch their business plans into commercially viable products and services.

IIM Ahmedabad has set up a Laboratory in Entrepreneurial Motivation that targets the fear factor involved in spurning or giving up a job to start out on your own.

Projects

Summer projects need not always be at high conceptual and analytic levels. Almost any corporate work, even at a relatively low or simple level (accounting entries, selling, field research), provides learning that would be useful.

Tata Institute of Social Sciences sends its students to the field for two days every week. This could be a good for business schools to follow, with students being required to go into the field on specific studies on a regular basis.

A template for project proposals might be developed to ensure that the projects meet certain criteria

- Investigation and interpretation
- Process-orientation and
- Purely academic.

Classwork and Self Study

a. Faculty-student ratio and faculty quality are inadequate for increasing the self-study component in India because self-study demands numerous assignments that the student undertakes for which he has to do a great deal of library work. It also requires faculty to examine and grade the assignments.

b. With many more management students fresh out of college and needing a great deal of basic management education (the semantics, contextual and legal framework, etc), unlike in the USA, there is little time to devote to the demanding pressures on both students and faculty if a high ratio of self-study was imposed. More self-study requires a conscious reduction of these other burdens on time.

   i. Soft skills (leadership, team working, emotional intelligence) need attention through class exercises. Most Indian management faculty appear to understand soft skills as communications skills. Emotional attributes like emotional intelligence, the ability to work in a team and develop inter-personal rapport and personality factors such as the ability to deal with ambiguity, tolerance (of diversity) and flexibility are part of it. Indian B-schools do little in this area and a study shows that at the end of two years the students may be worse off in these skills.

   ii. Yoga and meditation might be incorporated into the programme to help develop concentration, stamina and focus.

   iii. Testing and grading of soft skills is essential and ways must be found to conduct such tests.

   iv. For enhancing communication skills and several other soft skills, exercises such as debates, role-plays and elocution, participation in organising and managing social and cultural activities could yield good results.

   v. Using technology – video for feedback on

communication skills, networking for sharing videos of good orators etc—could be beneficial.

vi. MDI has a personal growth laboratory that helps students to understand their strengths. Students at FMS are helped to enhance their spiritual quotient, which is stated to be the sum of IQ and EQ.

Duration of the Program

Two years might be the minimum for freshers but could be shorter for those with work experience. A programme of duration of 12-15 months might be acceptable but demands a longer work year, very short vacations, full workweek, more self-study, long hours in the library, extensive group interactions, and many assignments that must be graded.

Using Workshops for Special Skills

Newly-minted managers are of three kinds: analytical, street-smart and workers. All three types are required in situations in which management skills have to be applied. These skills might be taught through special workshops organised for development of specific skills. Feedback, assessment and benchmarking are necessary for personality development, as is mentoring.

Role of Industry in Curriculum Development

- Companies can contribute hugely to immediate concerns on missing elements in the curriculum, share experiences, contribute faculty and help develop summer projects that will give experiences of reality.
- But companies rarely are able to conceptualise what needs to be taught to meet the needs of the future. That first requires forecasting the future. In this, social scientists must work with management faculty. B-schools must interact closely with sociologists, anthropologists, economists and political scientists to imagine the directions of the future society. The new challenges that future managers will have to face will have to be identified in these imagined future scenarios. B-schools must also bring technology forecasters into these discussions.

Faculty

Induction and Orientation

Management faculty come from different disciplines. It is essential that all faculty get management orientation at the outset. They must tailor their teaching to fit management education.

Institutes for Management Teachers

Like ICFAI has set up an ICFAI Institute of Management Teachers (IIMT), Hyderabad, to train people for faculty positions in business schools, the regulatory body could stimulate the setting up of a few more such institutes in the country.

Alliances

Alliances with local businesses are very critical and can be achieved by including local industry leaders on the boards of B-schools and by using them as visiting faculty.

Compulsory Updating of Faculty Skills

Compulsory retraining of faculty is important and may be done through 3-4 month training programmes or capsule programmes run by the better schools.

Faculty Work Norms

The AICTE norm that a lecturer must teach for a minimum of 16 hours per week must be refined to take account of all the different types of activities that faculty undertake and introducing standard norms and measures based on them: Those who are below standard could be given time and training to catch up and those that do not improve must be ultimately encouraged to leave. Those that exceed norms could receive substantial monetary and non-monetary incentives.

Research

A culture that is supportive of research must be created as an institutional priority. This can be done in three ways, viz.

- Themes that need special study over the next 5-7 years can be identified and funded
- Support must be given to individual project proposals.
- Institutions that have adequate support systems to start PhD programmes must be encouraged to do so.

Using Guest Faculty

Integration of guest faculty with core faculty must

be done consciously. They must be long-serving and not just for a term or year. They must also be available to students outside class hours. Guest faculty must not be more than 50 per cent of total faculty.

Student Evaluation of Faculty

Evaluation of faculty by final year students only should be encouraged but used only for faculty self-improvement, not for compensation review, though it could be a factor to be taken account of in promotions.

Viva in Admissions Tests

Viva (personal interviews) for student candidates reduces transparency admissions and encourages under-the-table deals. The viva should be replaced by a case study analysis during the written test. TOEFL type tests could be used to assess communication skills. Disinclination of faculty to go carefully through and mark the very large number of application forms and essays that a purely written admissions process involves, must be overcome.

Quantitative vs Non-quantitative in the Written Test

The SIA (Successful Intelligence Assessment) test even keeps that analytical, creative and practical abilities assessment of GMAT and tests candidates on the "acquisition and utilisation of tacit knowledge".

SIA does not include multiple-choice questions; instead, test-takers read about six scenarios – mini business cases – and write essays in response to questions about them. It is said that SIA has removed a major entry barrier for women and minorities at Kellogg.

Quotas

There must be no quotas for women or other groups. Scholarships could be in plenty to encourage students from socio-economically backward classes, non-English medium colleges and a short residential programme of up to three months could help to develop their confidence while training them to appear for the management aptitude tests.

Batch Size and Faculty-Student Ratio

Batch size for a class of less than 60 may make the number of students too few for various specialization streams in the second year. Much larger numbers will diminish close faculty student interactions.

Distance Learning

Distance learning with some contact classes and using electronic media could help reach management concepts and education to a larger population.

Expectations and Values

Expectations from MBAs

1. Recruiters look for dependable, proactive multi-skilled young people with can-do attitudes, who are able to work in teams. Hands-on projects and involvement in running selected activities in the institute, and other such work experiences in B-school could develop more such 'blue-collar' managers.
2. Recruiters also look for soft skills, perceptive managers, who are team workers, who have the ability and attitude to deliver performance; not necessarily problem-solvers, but people who can identify problems and analyze them.
3. A Cerebrus Consultants study (*Business India,* Oct 25 to Nov 7, 2004) found that companies were looking for potential "top leaders of tomorrow" with knowledge of tools and techniques and especially analytical skills together with reasonable social skills; readiness for operational roles such as sales, operations or back-office roles.
4. Recruiters' chief concerns were retention, especially of students from top-rung institutes and the need for in-depth career counselling in institutes to help students choose their first job correctly; soft skills like the ability to persuade and influence; awareness of the importance of teamwork; initiative; thinking of the organisation and not only of self. Institutes need to work actively on "attitude moulding".
5. Self-discipline is an important trait that has to be developed. Mentoring is critical. Outdoor training and team building exercises would help to impart physical, mental and moral strengths.

Attitudes, Ethics and Values

Humanity and Professionalism

1. Managers need to develop comprehension, compassion and courage and teaching efforts must be oriented to exercises and challenges that foster them.

2. Students with work experience bring the values learnt from observations at the work place. These may at times have to be consciously addressed, since they may be inappropriate.
3. We have to foster professionalism (systems and delegation) and the demystification of the corporate sector. Traits such as punctuality, the desire to help others and formal dressing, must be encouraged.
4. While there may well be "core Indian values", we need to keep religion out of this discussion. Some traits might be typically Indian – e.g., patriarchy, superstition, respect for elders, strong family ties, friendliness and warmth. Research must find out how some congruence with what is taught in management education could have come congruence with these "Indian" traits.
5. Profits and values are not incongruent but profiteering and values are. Companies are responsible not only for shareholder value but for all stakeholders including the community. Managers must learn how to balance the interests of all.

Placement and Remuneration as Top Value

Faculty must guide students to take up jobs in areas that interest them, rather than those that merely pay well.

Teaching Ethics, Inculcating Values

Ethics can be taught through practical examples; they could be integrated into all subjects or courses and can also be studied and inculcated through experiential learning. Management education should reinforce and not erode basic ethics and values.

Faculty and the institute best teach values when they demonstrate them in their dealings with the students and others. Each teacher could raise questions of ethics and values as he goes along teaching his subject or discussing a case.

Source: All India Management Association (AIMA)

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As a small businessperson, you have no greater leverage than the truth.

– John Greenleaf Whittier

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Issue No, 1-4

Articles

Book Reviews

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