NATIONAL PRODUCTIVITY COUNCIL

Productivity

Vol. 45 October–December 2004 No. 3

Focus : e-Governance

Guidelines for Contributors

Scope and Coverage

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

Format of Manuscripts

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

About the References

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

Accompanying Material

The manuscripts should be accompanied by:

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

Subscription

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

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

All business correspondence to be addressed to:

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

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

ISSN 0032-9924

Productivity

A QUARTERLY JOURNAL OF THE NATIONAL PRODUCTIVITY COUNCIL

Vol. 45 • October–December 2004 • No. 3

CBS

CBS PUBLISHERS & DISTRIBUTORS

New Delhi • Bangalore (India)

CBS PUBLISHERS & DISTRIBUTORS

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

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

ISSN 0032-9924

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

Printed in India.

Production Director: Vinod Jain

Contents

Software Management Tools in ICT for Government

S. Jagadish

The author's association with some of the ICT initiatives in government, particularly in Karnataka, shows that some software engineering tools can be used effectively to manage projects or take critical decisions. Using three specific instances, this article demonstrates the effective use of Function Point counting and Use Case diagrams. The author is for continuing and exploring the use of such techniques in e-government projects.

S. Jagadish is a professor at the Indian Insititute of Management, Bangalore.

If one were to look at the papers or listen to discussions about e-governance or the use of ICT (Information and Communication Technology) in government, they usually refer to theories of e-governance (of which there is none), description of successful e-governance or ICT initiatives, hypotheses of what would or would not make for good e-governance; or quite often, there are debates about the most appropriate technology to be used or investments to be made. Most concerns seem to hover around which among the many implementations are successful; how to implement and manage an e-governance initiative; what are the common defects in e-governance systems; what are the secrets of successful e-governance projects; what theories apply to e-governance, etc.

I want to share, through my own experience as an advisor for some e-government projects, my idea of how useful it is for government officials to become familiar with some software engineering/management techniques or tools that will help them manage their projects effectively.

I have often come across government officials who have picked up enough jargon of the IT world and often speak of RDBMS, Private and Public Keys, TCP/IP, TDMA/FTDMA and on, that they even confuse the technical representatives of the vendors.

While all this is good to know, I feel that there are certain techniques and tools that would help them much more in the management of ICT initiatives. The following case studies will shed more light on the issue.

Case 1

The state government of Karnataka embarked on a massive project to ensure smooth implementation of several projects involving investments from global companies following a global investors meet. One of the

measures taken to ensure that no delays were involved in sanctioning the projects and helping the investors to implement them was to develop an online monitoring system that could be accessed by the chief minister himself.

The system required that a district collector should be able to key in information concerning the projects to be taken up in his or her district and that this data should be available on a common data base with user-friendly access by all those authorized for information or report generation. Not only would this data be available on querying mode directly at the chief minister's office, formatted reports could also be generated on the progress of the projects. The chief minister should be able to identify bottlenecks, authorize required action, and could also receive complaints through the system.

As per usual procedures, tenders were called for an IT service provider to design and build this system and the contract was ultimately awarded to one of them. This included the fee, which was computed on the basis of total effort required but was to be paid at a monthly rate, on a quarterly basis, for a reasonable period till the completion of the project.

The project began in the middle of 2000 and went about smoothly with bills being cleared and paid promptly.

However, two bills, one for the last quarter of 2001 and the other, for the first quarter of 2002 came under dispute. The contention by the government was that this work should have been completed much earlier and that the vendors had fallen short of targets of late.

The argument of the vendors was that the accusation of the government wasn't true. The delay, if any, according to them was because the customer demanded a web version of the system, which was not intended at first.

In the early stages, the system was developed using Visual Basic and this was referred to as version 1.0. A web-based version, version 2.0 also began to be developed in April of 2001. That it didn't cause any disputes till the end of 2001 is questionable if the vendor's argument was to be accepted in toto. Both the parties agreed, therefore, that the situation called for an analysis and an objective assessment of the bill. This problem was referred to me as member of technical advisory panel.

What we needed was to measure productivity, relate it to the payment terms and check if the present bill conformed or needed some adjustment.

How does one look at productivity that involved software development when no previous logs of productivity were available? To begin with, we needed to assess, how much of "work" was acceptable and how much of "work" had been carried out.

This was where the concept of Function Points came to the rescue.

It goes without saying that any software that is developed to provide more functionality is expected to require more effort (or time), than one that provides less functionality. Given a set of requirements, the vendors are expected to meet them over time as they build the functions as they progress.

Function point count is a surrogate measure of functionality – the concept is explained, later, below – and is represented by a number. Thus a software of 1000 Function Points will be 10 time larger than a software of 100 Function Points, and so on.

Since no agreement existed regarding expected productivity or the delivered functions within a specific period, what was done in this case was to use the performance during the undisputed part of the project and use it as a baseline to compare the performance during the period of the disputed bill. Thus one could provide a rational basis to argue whether the vendors did take more time or the customers demanded more of them, etc.

What we did was to look at the software functions that were delivered each quarter, from the beginning to the end of July 2001, of version 1 and April to July 2001 of version 2 and performed a function point analysis. We found that the total function points developed was 317 and, by counting the number of people employed at various stages and for corresponding periods, the effort was found out to be about 25 person months.

This gave us a productivity of almost 13 function points per person month. Since this was part of the undisputed period, this was taken as the accepted standard.

A similar exercise was carried out for the amount of work carried out from August 2001 onwards and it was found that this part of the software involved about 483 Function Points and the effort put in was of 45 person months. This gave a productivity of 10.7, definitely lower than the set standard above. When this was pointed out, both the government representatives and the vendors could sit down and renegotiate the disputed bill to the satisfaction of both.

[Since both versions were carried out concurrently during the earlier part of development itself the earlier productivity could be accepted as standard. However, in other situations care should be taken to ensure fairness by adjusting for an acceptable level of productivity for a given technology. It cannot be the same for all.]

Thus there was an indisputable measure that could be used to discuss, record and if necessary, was available for audit. The alternative would have been long committee meetings, frayed tempers, mistrust and an uncomfortable relationship during the rest of the project.

Function Points

As mentioned earlier, a function point is a surrogate measure of the functionality that software provides. It is determined by applying a set of rules agreed upon by an international body called the International Function Point Users Group (like the Institute of Chartered Accountants).

Function point analysis is based on the premise that all software applications ultimately involve handling of data, feeding inputs and seeking or generating outputs. All functions are some form of this.

The software application being measured is split into two categories of functions: Data Functions and Transaction Functions.

"Data Functions", looks at the type and the number of files that the application has to handle. A file can be an Internal Logical File (ILF) or an External Interface File (EIF). ILF's are a set of logical grouping of data (files) that are maintained by the application that is measured. That is, these are the files in which the data are updated, modified or deleted. External Interface Files are not files within the application but are referred to during the application. An example of this would be a table of wage rates that would be accessed by a payroll application.

These files are determined for their complexity that is based on the number of data elements and type of records they contain.

"Transaction Functions", are the external inputs (EI), external outputs (EO) and external queries (EQ) that the application involves. For example, logging in a system is an external input, so is the feeding of any data; while, a formatted report would be an external output. An external query is when the information contained in a file is just pulled for viewing without any processing. Displaying a record is an example of an external query.

Next, the complexity of these functions is determined by the number of data elements involved and the number of files that the transaction has to refer to in doing so.

The Function Points of an application is then determined by counting the number of ILFs, EIFs, EIs, EOs and EQs, determining their degree of complexity – that is, low, average or high – and referring to the table like the one shown below:

Functional Size
(Unadjusted)

Function Type	Low	Average	High
EI	3	4	6
EO	4	5	7
EQ	3	4	6
ILF	7	10	15
EIF	5	7	10

The number of the above functions multiplied by their corresponding size from the table above and totaled up gives us the unadjusted function points. It is called unadjusted function points because we have not yet taken into account the system characteristics, namely whether the system has to be multi-accessible, how complicated is the network, if any, how rigid are performance standards, etc. Thus the above number has to be adjusted by taking into account the value adjustment factor or VAF. This is determined by 14 general system characteristics as given below.

1. Distributed Data processing
2. Data Communications
3. Performance
4. Heavily Used Configuration
5. Transaction Rate
6. Online Data Entry
7. End-User Efficiency
8. Online Update
9. Complex Processing
10. Reusability
11. Installation Ease
12. Operational Ease
13. Multiple Sites
14. Facilitate Change

The degree to which each of these characteristics

influences the software is rated on a five-point scale and totaled up.

If DI represents this sum then, VAF is given by VAF = DI X 0.01 + 0.65 and the final, adjusted function points is given by the unadjusted function points multiplied by VAF.

The Function Point Users manual (IFPUG, 1999), gives detailed information about how to identify the data and transaction functions and also to determine the degrees of influence.

It is important to note that the entire philosophy of Function Point counting is based on the users' view of the system. For, instance, function point analysts are required to keep off from the technology of the system. Files are considered to be logical grouping of data as envisaged by the user and not as ISAM files or RDBMS tables, etc. In fact the entire analysis is as viewed from outside the boundary of the application.

Case 2

Another case when the use of function point counting proved very useful was for a major project of the Karnataka government.

A particular software vendor had been engaged by the government to develop and implement a rather large ICT project. In the process, the vendor got to learn quite a bit about the functioning of the government, particularly related to this department. Therefore, when the same department wanted to initiate another, relatively smaller project (in fact an extension to the earlier project), they would prefer the same vendor to take up the job. However, government procedures would require them to float tenders and, thanks to the transparency act, no negotiations were possible with the vendors until the lowest bidder was identified. There was one way out, however.

Government procedures allows one to place orders on the same vendor, without seeking fresh quotations, provided that the order is for a similar item and within a specific period of the previous order. This is treated as a repeat order and the price paid for the item should be the same as that of the previous order.

It was decided to take advantage of this possibility because, as software, it could be treated as a similar item. The only issue was of fixing the same price as before. Function points were again taken recourse to.

What was required was to find some measure for the size of the earlier software and pay for the corresponding measure of the proposed project at the same rate paid for the earlier one.

This was very simple. All one had to do was to go back and count the function points of the application already delivered, divide the total bill amount that was paid for and get a rate per function point. Next, the function point count of the new application was determined and it was multiplied by the rate calculated above, to get the price that could be paid for without attracting legal or audit objections. In fact, this rate was fixed as a permanent figure for all subsequent negotiations and comparisons. This particular vendor now flaunts the function point metrics and the other derived measures not only as a selling point but also as a strength of its management capability.

Function point counting can thus be a very useful measure for all government ICT projects: it does not depend on any technology, can be learnt easily and become an effective tool of communication between vendor and customers. Moreover, with metrics derived out of it, like productivity, price rates, effort required, calendar time, etc., government projects can be managed very effectively.

There is a related estimation technique called COCOMO, for Cost Construction Model, which, with function points, can be used to estimate effort and schedules in a more scientific manner (Boehm, 2000).

Case 3

One of the most difficult aspects of an ICT solution is to understand what really is required. This is much more so in government projects because the decision-maker consists of a committee which itself is not clear of what it wants since each member has their own idea of the requirement.

One of the most difficult aspects of an ICT solution is to understand what really is required. This is much more so in government projects because the decision-maker consists of a committee which itself is not clear of what it wants.

What usually happens is that representatives of the vendor sit with some officials of the department, understand some of the relevant processes and draw some flow diagrams. Then they sit with some officials and

members of the committee, seek clarification about the requirements and then finally make a presentation.

The presentations consist of a summary of the verbose description of the requirement, as they have understood them, some flow diagrams to explain what they have understood of the processes and how their solution addresses them and, usually an idea of how their system will look like by presenting an example of the computer user interfaces. Examples of these screens are shown in annexures 1 and 2. These are supposed to have covered all the functional requirements of the system. The audience is expected to assess whether this is what it had in mind in terms of requirement and provide necessary feedback that will enable the vendor to either explain or make adjustments in their requirement specification.

The presentation is backed up by bound volumes of copious descriptions and technical diagrams confirming the requirements in detail.

Thus the government representatives are expected to read and remember all the verbose descriptions, understand the flow charts, etc., to assure the vendors that they had got it right and could go ahead with the design and implementation of the application.

This never happens. The interface screens, in fact only tell you, at best, whether the particular operation or transaction gets covered as preferred. They never tell you whether all that has to be done by the system is covered. Moreover, vendors have an inherent tendency to cover up absence of clarity with technical jargon and diagrams; and, the requirements, or whatever is understood of it, is also written in a way for the engineers to understand and help in developing the application. It remains a mystery to the user community.

Requirements can never be captured fully and that's a fact. However, there must be better means of communicating with the users so that they know what the system is expected to do.

A situation of this kind existed when it was decided to introduce an online system for the management of the gram panchayat treasury operations: the vendors studied the system and were expected to make their presentations to the group of CEO's who were responsible for managing these treasury operations. The vendors came up with verbosity and screen diagrams as per standard practice. It was, however, very necessary that the CEOs feel that the vendors had captured all that is expected of the system. This is where we took recourse to another software engineering tool.

'Use Cases' are a method of capturing and depicting requirements that fall under what is known as the Unified Modeling Language (UML). It consists of Use Case Diagrams, transition diagrams; use case descriptions, etc. that ultimately help a software developer design the system using object-oriented methods.

The Use Case diagrams are simple sketches that indicate how a system is used, from the outside. It consists of actors and "Use Cases", representing functions to be covered by the system. It is very easy to understand these diagrams. Hence, in this case, the vendors were asked to present the Use Case diagrams, a sample of which is shown in annexure 3.

Now it was much easier for the CEOs to say whether or not the vendors had captured all that happens in the treasury system and if that is what has to be included in the proposed system. They could view it, take copies of them, study them leisurely and discuss it with others before commenting on them.

This has been found useful enough for me to recommend this wherever possible. Those interested in knowing more about use cases can refer to Jacobson, 1998.

Finally, the most useful and powerful tool of software engineering/management that could be used in e-governance projects is a project management tool, like MS Project or Primavera, for planning and monitoring the project.

The most useful and powerful tool of software engineering/management that could be used in e-governance projects is a project management tool, like MS Project or Primavera, for planning and monitoring the project.

This seems very obvious, but I have never seen the tool used to its full advantage anywhere so far.

The vendor is asked to give a schedule and this is provided in the form of a bar chart – that may or may not be derived out of a formal method /tool –that remains static. It is never referred to during the actual monitoring of the project. The reason is obvious: because no one knows how the plan was prepared, how resources were assigned and how schedules were drawn. Only if these were done and shared with the steering committee can any dynamic monitoring be done.

A proper use of these tools first of all requires formal training in PERT/CPM techniques, followed by the technique of using, say, MS Project. This requires a thorough analysis of time and resources before a schedule is accepted. Once the schedule is accepted, the timeline, effort and costs become the baseline. Once the project is underway, it should be updated periodically, by reviewing the actual performances against these parameters. This will not only give a good command over monitoring the project, but it also provides good data for generating metrics for use in future projects.

Metrics

Metrics is the term used for measures that are useful for managing IT projects effectively. There are basically two kinds of metrics – primary and derived.

Function Point, is a primary metric, for all it is determined directly and indicates a single measure, namely the size of the application, whereas the productivity that was computed required two measures, namely function points and actual effort. Productivity is therefore a derived metric. Effort itself is usually a derived metric determined through algorithms like COCOMO or derived through primary and secondary standards captured directly or computed using past performances.

As the saying goes, "what cannot be measured cannot be managed". So, government officials undertaking ICT initiatives should learn about and introduce metric capturing plan. This will reduce some of the problems considerably and help manage their projects more effectively. I believe that we can think in terms of a maturity level model for departments and states based on the degree of metrics they use in managing their projects.

Some of the basic metrics that should be maintained are:

- Size
- Actual Cost
- Estimated Cost
- Actual Duration
- Estimated Duration
- Number of people involved

They are easy to maintain and should be analysed often to derive more relevant metrics.

Conclusion

One could give several examples of the above kind, but suffice it to point out how the techniques of IT/Software engineering tools can be used to manage e-governance projects effectively.

Most State Governments choose some officers to take up the responsibility of CIO's and send them for training. The training consists of Database Management Systems, Information Technology, Structured Systems Analysis and even Programming in Visual Basic or C++. None of them is actually useful in their nature of work. They were meant to be administrators and managers and that's what they should adhere to. Quite often partial knowledge leads to more confusion.

On the other hand, if they were given training in management of projects with topics related to software management in particular, it would turn out to be more meaningful. This is in addition, of course to other management issues like vendor selection and analysis, contract management project evaluation, etc.

The International Function Point Users Group (IFPUG) holds an annual conference every year when training in both basics and advanced function point analysis is offered. Many of the participants of these courses are officials of the US government. Similarly, a one week training in Function Points, Testing, Project Planning and Monitoring will make a far greater difference to the e-governance projects in India than the traditional technology-based training given to government officials.

References

Boehm, Barry, et al. (2000), "Software Cost Estimation with COCOMO II", Prentice Hall PTR.

IFPUG, "Function Point Counting Practices Manual, Release 4.1", Chair Person, Counting Practices Committee, 1999

Jacobson, Ivar, et al. (1998), "Object-Oriented Software Engineering – A Use Case Driven Approach", Addison Wesley.

□

E-Government: Steps Toward Nirvana

M.P. Gupta

The advent of Internet has made it possible for the government to become e-enabled. This gives the government the opportunity to react to citizen and business demands by offering new methods of service delivery. Indian government has taken many steps towards e-governance, but this path is fraught with many difficulties, including possible security threats.

M.P. Gupta is Associate Professor at Department of Management Studies, Indian Institute of Technology, Delhi.

Internet is a revolution of a kind that happens once in centuries. In the communication domain it has come to offer an opportunity of a lifetime. Going online for a Government means a single point of access to all government information and greater citizen interaction with the governments via on-line and Internet-based services in an organized and efficient manner. It also means potential for conducting government business and activities in a more cost-effective and efficient manner.

Business of Government

The traditional form of government has performed well in the past. However, in the modern world there is a need for better systems on part of the government to handle issues swiftly. The availability of technology has made it possible for the government to take steps in the direction of being e-enabled and transformed into Government-on-line. It offers an outstanding opportunity to react to citizen and business demands by offering new methods of service delivery to meet new expectations. Some common points that will be addressed by an e-government are:

- Citizens will get online access to government information. This is otherwise, very difficult as citizens may have to go to government offices and stand in the queue for hours to get some information.
- There will be more transparency in the government systems.
- There can be a check on corruption.
- Citizens will find it easier to access the government departments and lodge their complaints with them.
- The Government will be able to respond faster and be more efficient.

Thus, the change will bring many advantages for the citizens. It has been extremely crucial for the government to take steps to become an e-Government.

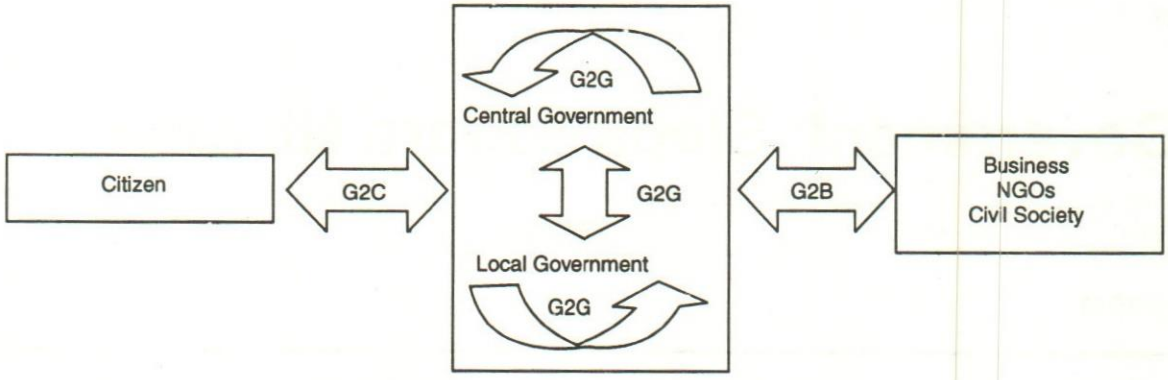


Fig. 1. Interactions between main groups in e-governance

The terms e-government and e-governance are often loosely used but they are different. An e-government is an administration where citizens can avail of government services such as land records, filing of tax, etc, while e-governance involves the formulation of laws and regulations to govern cyberspace, such as domain names, etc. As contemporary research and initiatives reveal e-governance has two definite connotations - the application of *electronic means* in the *interaction* between *government* and citizens and government and businesses, as well as in internal *government operations* to simplify and improve all the aspects - democratization, governmental and business aspects of *governance* (Backus Michiel, March 2001, IICD research brief (No-1). The term "*interaction*" stands for the delivery of government products and services, exchange of information, communication, transactions and system integration. *Government* consists of all levels and branches which includes central/national, regional, provincial, departmental and local government institutions. *Government operations* are all back-office processes and inter-governmental interactions within the total government body. Examples of *electronic means* are Internet and other ICT applications.

The Gartner Group describes "E-government as the continuous optimization of service delivery, constituency participation, and governance by transforming internal and external relationships through technology, the Internet, and new media." E-government is itself a process, or a means to an end, rather than an end in and of itself. E-government is still in the earliest stages of development and promises to evolve with advances in technology and increased acceptance and trust in electronic communications.

Although e-government encompasses a wide range of activities and actors, four distinct sectors can be identified. These include government-to-government (G2G), government-to-business (G2B), government-to-citizen (G2C), and government-to-employee (G2E). The G2G sector represents the backbone of e-government. G2G e-government involves sharing data and conducting electronic exchanges between governmental actors. This involves both intra- and inter-agency exchanges at the national level, as well as exchanges between the national, provincial, and local levels. Government-to-Business (G2B) receive a significant amount of attention, because of the high enthusiasm of the business sector and the potential for reducing costs through improved procurement practices and increased competition. The G2B sector includes both the sale of surplus government goods to the public, as well as the procurement of goods and services. G2C initiatives are designed to facilitate citizen interaction with government, which is the primary goal of e-government. These initiatives attempt to make transactions, such as renewing licenses and certifications, paying taxes, and applying for benefits, less time consuming and easier to carry out. G2E interface can cover employment opportunity to work guidelines, rule and regulations, salary structures, leave provisions, code of ethics, medical retirement benefits and welfare etc.

In addition, there are three levels of e-government:

- Low-cost services, such as information and forms;
- Transaction services, such as tax payments, parking fines, business permits or electronic catalogues for purchasing; and
- Integrated e-government services, including web portals that can be customized to fit personal needs, and local services arranged around life events, such as moving, going to school and finding a job.

Vast improvements in computing, networking and telecommunications have led to a surge in technology investments at the federal, state and local levels that will continue to grow. E-government is expected to

have an immense presence in the years ahead. The first signs of its impact are already becoming apparent. Cities and towns in US spent an estimated $500 million in 2000 for e-government-related activities, and spending is expected to increase to $1.6 billion by 2003, according to the Meta Group. By 2006, all sectors of government will collect about 15 per cent of fees and taxes online, which will amount to $602 billion, according to Forrester Research (http://www.westerncity.com/June01E-Gov.htm). In addition to improving government functioning, e-government also helps to grasp the economic changes already under way. In 1999, online transactions were worth $145 billion. By 2004, the estimated value will be $7.3 trillion (http://www.westerncity.com/June01E-Gov.htm).

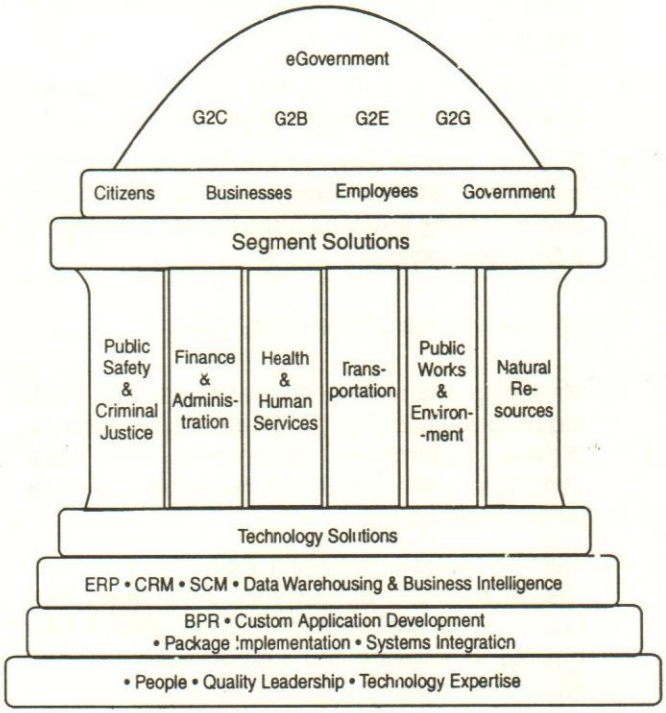


Fig. 2

Source: www.wipro.com

The biggest reason for this is the lower cost of transaction on the Internet. When an airline ticket is purchased online, the transaction costs 87 per cent less than by traditional means. An online banking transaction is 89 per cent less expensive; bill payments, 70 per cent; an insurance policy, 50 per cent. The issue of lower costs is extremely important to local governments, and e-government can help reduce costs. As per the 2002 iDC study, over the coming years governments around the world will increase their spending on e-government initiatives as they devote more resources to e-enabling government business functions and providing electronic services. Governments across the Asia-Pacific region are launching ambitious e-government initiatives, using electronic technologies to improve both internal operations and public service delivery. Of the five governments profiled, Australia, China, Hong Kong, Korea, and Singapore, e-government spending will grow the fastest in China at a compound annual growth rate of nearly 40 per cent. Meanwhile, e-government spending in Singapore and Korea will experience robust growth at over 20 per cent over the forecast period, and e-government spending in Australia and Hong Kong will grow steadily at 15 per cent and 13 per cent respectively. This creates major opportunities for IT vendors and service providers as the public sector seeks advice, products, services, and partnerships in implementing e-government projects. Currently, most governments are at the stage where they have a narrow focus on providing electronic services and achieving agency-by-agency operational efficiency – without fully considering the benefits they can achieve by approaching it as an ebusiness transformation. The sophistication of their services and systems will grow and new opportunities will emerge as they progress along the e-government maturity curve.

The Indian government, realizing the importance of IT, has created a separate Ministry of Information Technology to promote IT in the country. The Government has also approved the policy of allocation of 2 to 3% of the budget for IT. According to Nasscom projections, state governments and the Central government combined are expected to spend $890 million towards e-governance in 2001-02, a number which is expected to reach $6 billion in 2007-08. According to the Gartner study 2003, the Government of India is the most recession-proof vertical that could keep the momentum in Information Technology (IT) alive across countries in the Asia Pacific region. As per the estimates the Indian government has emerged as the fourth largest vertical spender on IT in the country following the verticals of telecom, manufacturing, and banking and finance. The IT spending generally includes hardware, software, telco equipment, telco services and IT services. The government is estimated to have spent $1.008 billion in 2002 accounting for nine per cent of the total IT spend. By 2005, the Indian government's IT spending would hover between 12-15% of the total domestic ICT spend. The combined spending on IT across APAC governments in 2002 is $15.2 billion and estimated to touch $20.2 billion by 2005.

The commencement of the IT Bill gives legal recognition to electronic documents. It will facilitate on-line transactional services on Internet. Some cases of the Indian e-governance initiatives at the district administration or police administration bear testimony as to how IT is being conceived as an important agenda of public administration in India. Further, the Government of India

(GoI) had declared 2001 as the 'Year of e-governance'. However, according to Gartner, meaningful e-governance in India is unlikely before 2010, as only 10 per cent of government bodies around the globe will be able to move towards e-governance by 2005, and India is absent from the picture due to poor infrastructure and slow response to cyber-culture. According to Gartner, the transition from governance to e-governance takes place in four phases, beginning with a "presence" phase, followed by "interaction," "transaction" and the final "transformation" phase. India is still in the earliest phases of its transition. Flexible demographics and geographic competition within the country could eventually propel e-governance to prominence in India though the constraints are significant enough to stymie any immediate advances. However, the better aspect of the above estimates nearly a billion dollars spent in 2000-01, which tells a different story, signifying a growth of more than 60 per cent over the last year. These hard numbers are ample testimony to the vital importance of e-governance to India. According to Nasscom president Kiran Karnik, "E-governance must be a high priority for India, as it is the only means of taking IT to the masses. Additionally, this is a smart and economical process of building the Indian domestic software market."

While there are many emerging programmes and initiatives on e-government throughout the world in all levels of government, these initiatives present a number of challenges in terms of policy, infrastructure and security etc. The objective of achieving e-governance goes far beyond mere computerisation of standalone back office operations. E-governance has to fundamentally change how a government operates and this implies a new set of responsibilities for the executive, legislature and the citizenry. The government is aware of this fact as is obvious from the statement of Arun Shourie, Minister of Communication, IT and disinvestment, "The government's IT managers should develop a minimum agenda for e-governance. The days of 'file culture' had come to an end and cumbersome procedures should soon be replaced by online decisions".

The days of 'file culture' had come to an end and cumbersome procedures should soon be replaced by online decisions.

To bring about a successful change in the government system requires bringing change in the mindsets of people both inside and outside. Managing change refers to getting the users to accept a new organizational process and the technology that enables it. New applications or processes that fundamentally change the way people work and their relationships with others may require some formal change management programme. Change management is about helping people deal with their emotions. It is important to manage the human element for the success of any new system or process.

Communication, training and organizational restructuring are the key areas to be covered within the scope of change management (http://www.moict.gov.jo/MoICT_Change_Management.aspx).

Communication includes:

- Creating awareness on e-Government programmes, promoting key activities related to the programme and motivating the achievement of key goals and objectives
- Participation in defining key messaging to different audiences at different levels
- Support in providing government entities with orientation on e-Government programmes and also providing a helpful template for developing a business case.

Continuous training and learning include:

- Managing e-Government related national training programmes. The programme should aim to provide government employees with basic computer skills which will help them perform their job efficiently.
- Training needs assessment staff, where specialized training and activities for transferring best practices to the staff is planned and implemented to motivate and support the mission of each personnel.
- Transfer knowledge to other government entities with regards to the methodology and standards. This is done through workshops, events, and training sessions to have consistency in implementation of project management, programme management, technical standards, and change management.

Organizational review and restructuring has a high priority at the level of e-Government projects implementation. This can be done through:-

- Initiative inception starting with organizational preparation.
- Internal annual review for organization structure to map the existing structure to the current

situation and work requirements. Gap analysis and recommendations are communicated accordingly. This is done as part of the organization and resources utilization to accommodate the new state of change.

- Business Process Re-engineering (BPR) – as a key requirement in most of the e-Government initiatives/projects to map the transformation process planned to take place.
- Enhancement of customer services – this includes both internal and external customers.

The *Best Practices in Change Management* (http://www.prosci.com/chg9.htm) report presents comprehensive findings from 288 companies on their experiences and lessons learned in change management. This report makes it easy to learn change management best practices and uncovers the mistakes to avoid when creating executive sponsorship. The findings of the report include:-

- The number one contributor to project success is strong, visible and effective sponsorship.
- The top obstacle to successful change is employee resistance at all levels: front-line, middle managers, and senior managers.
- Employees want to hear messages about change from two people: the CEO or their immediate supervisor (and these messages are not the same).
- When asked what they would do differently next time, most teams would begin their change management activities earlier in their next project, instead of viewing it as an add-on or afterthought.
- The top reasons for employee resistance are a lack of awareness about the change, comfort with the ways things are and fear of the unknown.
- Middle managers resist change because of fear of losing control and overload of current tasks and responsibilities.

In the context of the government, similar thoughts will be true and the government needs to address these issues to handle change effectively. Along with wise and effective leadership, e-government planning requires the following:-

- A well-thought out organizational structure that involves all stakeholders, including the community;
- Risk management procedures that can bring about change in old business processes without allowing turf battles and staff alienation to stall progress; and
- An assessment of the jurisdiction's readiness for e-government - This includes assessing all strengths, weaknesses, opportunities and threats.

E-Business

It is believed that Internet development will ignite an economic transformation on a scale of the industrial revolution. It is already making sweeping changes at our work places. The last time something as important as the Internet happened to business was in the middle of the nineteenth century when the railroad changed the world. The transition took 50 years (Treese and Stewart 1999). The Internet transition is happening much faster. To understand the business potential of Internet, it is necessary to first understand the railroad. The railroad was first introduced in 1825 and become the dominant mode of transportation in the world. Some of the changes brought are shown in table 1.

Table 1: Changes wrought by Rail transportation (Treese and Stewart 1999)

	Before the Railroad	After the Railroad
Travel between NY & Boston	4 days	< 1 day
Transportation depends on	Weather & location of waterways	Ability to lay rails
Workforce	Dispersed (92% of population in 1830 is rural)	Concentrated (50% of population in 1920 is urban)
Vacation	Near home	Away from home
US time zones	8,000	4
Transport cost	5-15 c/ton/mile in 1825	1 c/ton/mile in 1884

Today the Internet is remarkably similar to the nineteenth century's railroad infrastructure development except that the Internet is happening much faster. Consider some of the factors shown in table 2. The last entry in the table is particularly important-both the railroad and the Internet accelerated a fundamental economic change that was already underway. In case of the railroad, cheap transportation accelerated the industrial revolution whose key enabler was the steam engine. In the case of the Internet, cheap communication is accelerating the information age whose key enabler is the computer. The ability to route goods by rail between arbitrary factories accelerated the industrial revolution.

Likewise, the ability to route information between arbitrary computers is accelerating the information age. What is required in business is a sense of foresight in identifying opportunity and strategic planning. We have examples of Wal-Mart which waited 12 years and built 78 stores before it reached annual sales of $150 million. On the other hand Amazon achieved the same sales in two years with no stores, one website and a warehouse.

Table 2: Comparison of Railroad & Internet Infrastructure (Treese and Stewart 1999)

	Railroad (1825-1890)	**Internet** (1969-1997)
New infrastructure	First water-independent transport infrastructure	First global public information infrastructure
Original purpose	Passenger traffic; military	Military & civil defence; research
Importance of standards	Width of tracks (gauge)	Network & communication protocol (TCP/IP)
New security challenges	Railway police to control new crimes	Security protocols and standards
Source of innovation	Steel production, accounting, logistics	Software, networking, fibre optics
Accelerate fundamental economic change	Industrial age (Key enabler: steam engine)	Information age (key enabler: computer)

Internet has created new universal space for information sharing, collaboration and commerce. This has created a new environment of business with increased intensity of domestic and global competition. In this complex and competitive environment, organizations are in search for efficient and effective ways to manage their businesses. To thrive in the e-commerce world, organizations need to structurally transform their internal foundations to be effective. Visionary firms are setting new rules within their industries via new techno-business design, new enterprise processes, and integrated operations to support changing customers requirements. They realize that the next wave of customer-centric innovation requires businesswide integration of processes, applications and systems on an unprecedented scale. According to Kalakota, this business wide integration is a result of a planned strategic change and is called e-business. E-business initiatives are possible on a sound architecture, which consists of well-integrated building blocks called enterprise applications that include, Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Human Resource Management (HRM) and Supply Chain Management (SCM). These applications demand a higher IT budget. E-business has proved to be a success for

Table 3: Alternative Definitions and Views of e-Business:1999 to 2001 (Alter et.al. 2001)

"Electronic business" ... "includes everything having to do with the application of information and communication technologies (ICT) to the conduct of business between organizations or from company to consumer." [Huff et al. 2000]
"E-business includes e-commerce but also covers internal processes such as production, inventory management, product development, risk management, finance, knowledge management and human resources. E-business strategy is more complex more focused on internal processes, and aimed at cost savings and improvements in efficiency, productivity and cost savings." [Bartels, 2000]
"The use of the internet and other digital technology for organizational communication and coordination and the management of the firm." [Laudon and Laudon, 2001]
"E-business is the complex fusion of business processes, enterprise applications, and organizational structure necessary to create a high performance business model." [Kalakota and Robinson, 1999]
"It is important to note thatg e-business is much more than electronic commerce. E-business involves changing the way a traditional enterprise operates, the way its physical and electronic business processes are handled, and the way people work." [El Sawy, 2001]
IBM defines e-business as "a secure, flexible and integrated approach to delivering differentiated business value by combining the systems and processes that run core business operations with the simplicity and reach made possible by Internet technology". [Stolee, 2000]
"E-business is about using Internet technologies to transform the way business processes are performed. Its most visible form is online purchasing, both wholesale and retail." [Shurety, 1999]
"In its simplest sense, e-business is the use of Internet technologies to improve and transform key business processes. Most companies understand this and have begun the evolution from traditional business practices to e-business." [IBM, 2000]
"E-business: any Internet initiative – tactical or strategic – that transforms business relationships, whether those relationships to business-to-consumer, business-to-business, intrabusiness, or even consumer-to-consumer. ... E-business is really a way to drive efficiencies, speed innovation, and new value creation in an organization." [Hartman, Sifonis, and Kador, 2000]
"By connecting your traditional IT systems to the Web you become an e-business." [Amor, 2000]

organizations. There are many advantages of using technology for various business processes. Internet helps organisations to serve their customers faster and more efficiently. E-business models have helped to reduce cost considerably by cutting down the time in various business processes. The entire cycle from the supplier to the customer becomes faster and it has the capacity to address to the changing needs of the customer. ERP and SCM have improved the business systems. CRM has played an instrumental role in satisfying the needs and aspirations on the customer's side.

The term "e-business" was popularized as the

slogan for a conscious strategy launched by IBM in October 1997, to position IBM as a cutting-edge company and shake off for good its image as a stodgy, if reliable, supplier of computers to giant corporations. IBM owns the trademark on a styled lower case "e,". However, e-business emerged subsequently as a formidable concept following the pervasiveness of the Internet. Many experts attempted to define e-business and a model of the same. Table 3 presents a set of formal or implied definitions of e-business presented in a number of books and articles found in 1999 and 2000.

Competition drives business to e-business. The Government does not face any competition. It is *the only* service provider to its citizens: a crude monopolistic scenario. On the other hand the same 'citizen' in the market scenario is treated as 'customer' and therefore becomes subject of special attention and care. There are large number of competing offers of better products and services. Everyone is concerned for customer care in order to outdo others in selling the product or services. Coincidently, IT has revolutionized the entire gamut of doing business and customer care. E-business brings new technology and new capabilities to business, though fundamental business problems are those that have been faced for thousands of years i.e. you must have something to sell, make it known to potential buyers, accept payment, deliver the goods or services and provide appropriate service after the sales. Most of the time firms remain engaged to build a relationship with customer that might bring repeat business. Success of e-business offers an opportunity to federal and state governments to learn lessons from this. It is prudent to borrow and adopt the best business practice into its own system and thereby improve citizen servicing. The government depends upon taxpayers money with the binding of some serious responsibilities toward its citizens. E-business strategy is one and might be the last chance for the government to become efficient and effective in the delivery of its responsibilities.

E-governance projects will face problems and challenges similar to what were faced by e-business models. The Government needs to focus on the learnings from the failure and success of various e-business projects and incorporate them in order to assure that the similar mistakes are not committed again. The challenges in front of the government today are similar to the ones that were in front of e-business players a few years ago.

Government-on-line

Government-on-line as a concept is different from the traditional model of the government. Government-on-line is supposed to provide information, services or products through electronic means, by and from governmental agencies, at any given moment and place, offering an extra value for all participating players. This model of government provides various entities the facility of accessing the systems online in order to improve the efficiency of the parties. Here, the government will be able to put all three interactions i.e. Government to citizen, Government to industry and government to other governments (state governments) via the electronic route. The portals encapsulate the size and complexity of government, which for so long have been barriers to easy access of government services to citizens.

Table 4: Generations of corporate portals (adapted from Eckerson, 1999)

Generation	Category	Corporate portals
First	Referential	Search engine, with hierarchical index of web content. Each index entry contains a description of the content object and a link to it. The generation emphasizes content management, mass dissemination of corporate information and decision support.
Second	Personalized	Through identification and a passord, users create a personalized view of portal contents, known as "My page". This view shows just the categories each user is interested in viewing. The portal can notify users when new content is added to categories they have previously selected. Users can publish documents to the corporate repository so that other users may view them. This generation privileges content customized distribution.
Third	Interactive	The portal embeds applications that improve employees' productivity, such as e-mail, workflow, project management, expense reports, calendars, schedules, etc. This generation adds the collaborative character to corporate portals, providing multiple types of interactive services.
Fourth	Specialized	Portals based on professional roles, for managing specific corporate functions, such as sales, human resources, finances, etc. This generation connects corporate applications with the portal, allowing users to execute transactions, read, write and update corporate data.

Internet portal is one window to realize the sprit of Government-on-line. It provides people with a single door (web interface) into government. It allows for self-service, whether the citizen is looking for information, checking property assessments or paying a fee to use the local recycling centre. Portals are available all day,

every day, making them convenient and relatively hassle-free. The same portal is convenient for businesses, and helps them save time by allowing them to incorporate as a new business entity, apply for business permits and file corporate taxes online. In addition, businesses can search for opportunities with government, download and respond to requests for proposals, bid at government auctions of surplus materials, or put their own supplies out for bid. According to Douglas Holmes, "e-government would never succeed if people were expected to deal with a quadzillion different departments and agencies, each with their own website. So the web portal rode to the rescue, promising to be the magnet to find the needles in the public sector haystack".

Portal as an instrument of e-Government is still in its infancy (Eymeri, 2000). Portals have also followed an evolutionary stage of growth (Table 3). In most of the cases, it is static websites that provide information to citizens. Only a few nations (mainly within the EU, Australia, the USA and only a few in Asia) provide more advanced services and functionality. The one-stop Government concept is rather rare. However its varying degree of covering more and more services largely depends on the form of Government and the constitution of the respective country. There are several points where legal competence may impact the development and implementation of e-Government processes. Laws, judicial decrees and governance decisions are to be considered as knowledge repositories. Implementing a full government-on-line will possibly invite a huge organizational change. Governmental structures, traditionally, are rather fragmented into functional units that are independent of each other. E-government—and specifically one-stop government—calls for an integration and networking of public authorities, which will have a tremendous impact on organizational structures and responsibilities, on data access and on the way governmental work will be performed in the future.

Eckerson's fifteen rules given in Table 5, summarize the main features that a corporate portal should have.

The examples of Government-online include the government of Singapore, which has a portal where citizens can access government departments, get information and carry out transactions. In Singapore, the National Computer Board was set up in 1981 and the computerization programme in the Government Departments was intensified in the latter part of 1980. Singapore is a perfect example of a compact well-managed system, which has come to be known as an intelligent island with all pervasive use of IT.

Table 5: Main features of a corporate portal (Eckerson, 1999)

Characteristic	Description
Easy to use	Users should easily locate and access the right information, with minimum training, wherever the information is stored. Finding business information through the portal should be as simple as using a web browser.
Intuitive classification and searching	The portal should be able to index and organize the corporate information. Its search engine should refine and filter information, support Boolean operators and keywords, and present the search results in intuitive categories.
Collaborative information sharing	The portal should allow users to publish, share and receive information from either users. When publishing into the corporate repository, the user should be able to specify which users and groups may access his document objects.
Universal connectivity to information resources	The portal should provide wide acccess to every information resource and connect to heterogeneous systems, such as e-mail, databases, document management systems, web servers, groupware, audio and video systems. It must be able to manage different formats of structure and unstructured data.
Dynamic access to information resources	The portal should allow dynamic access to information and objects created by business intelligence and document management systems. It should always provide up-to-date information.
Intelligent routing	The portal should be able to automatically distribute reports and documents to selected users.
Integrated business intelligence tool	To fulfill users information needs, the portal should integrate search, report and analysis capabilities in its business intelligence component.
Server-based architecture	In order to support a great number of users, high volumes of information, simultaneous services and sessions, the portal should be based on a client-server architecture.
Distributed services	For load-balancing purposes, the portal should distribute its application services across multiple computers or servers.
Flexible permission granting	Portal administrators should be able to define permissions for users and groups within the company, through flexible user profiles.
External interfaces	The portal should be able to communicate with other applications and systems.
Programmatic interfaces	The portal should also provide programmatic interfaces (API ... Application-Programming Interface) in order to be "calable" from other applications.
Security	For security purposes, the portal must support cryptography, authentication firewalls, etc. to safeguard corporate information and prevent unauthorized access.
Easy deployment and maintenance	The portal should provide an easy and centralized way to manage all corporate information and to monitor portal's functioning. It should be easy to install, configure and maintain.
Customization and personalization	Administrators should be able to customize the portal according to enterprise policies and expectations. It should be allowed that individual users personalize their interfaces as well.

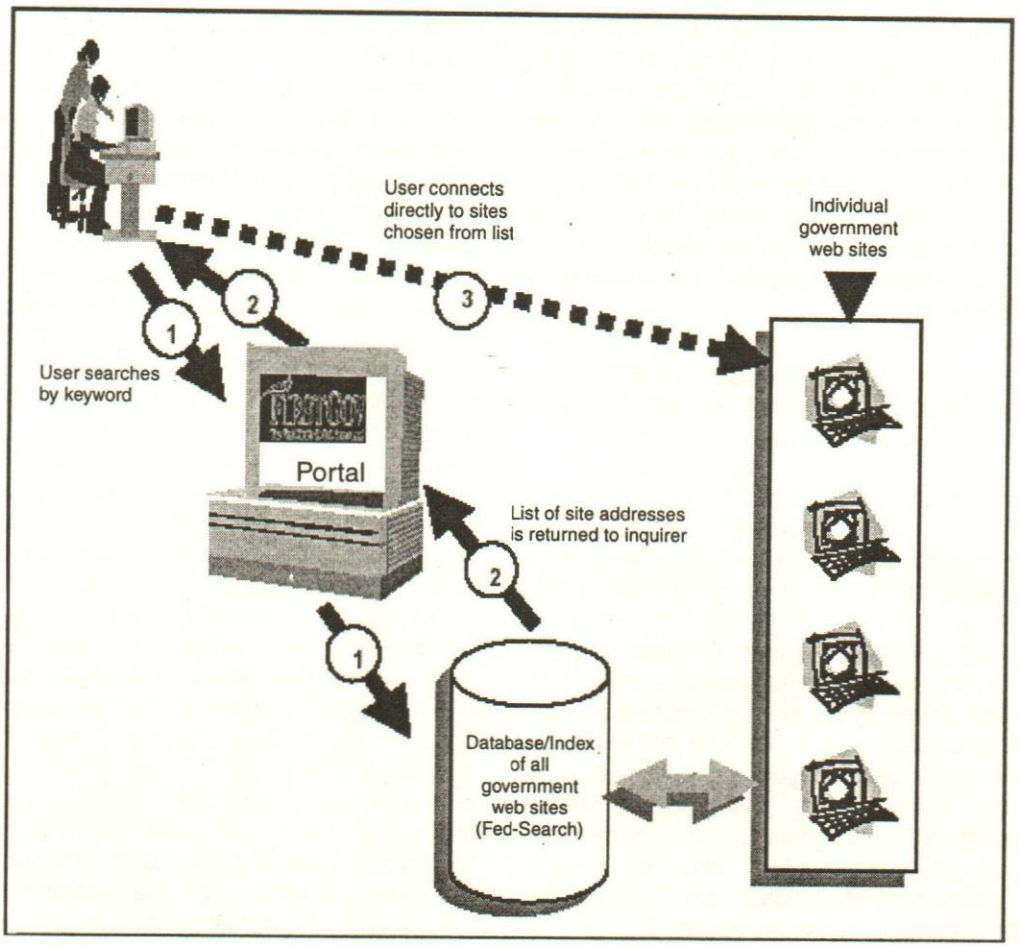


Fig. 3. Typical FirstGov.gov Search Process (McClure 2000)

In US, FirstGov.gov, is the administration's new website that is intended to serve as a portal to all of the federal government's publicly available, on-line information and services. It links the government's 20,000 websites and 500 millions of web pages and make it possible for citizens to obtain the information and services they need without having to ponder which federal agency controls which function. It was launched in September 2000 necessitated by the independent efforts of federal agencies in providing an array of on-line or e-government services. Although the predominant service available to date involves the collection or dissemination of information and forms, government agencies at both the federal and state levels have also begun enabling citizens and businesses to perform such functions as buying and paying for postage stamps or commemorative coins, submitting bids and proposals for government contracts, and renewing drivers' licenses. These changes were brought by Presidential directives, legislative mandates – such as the Government Paperwork Elimination Act (GPEA) and the Electronic Signatures in Global and National Commerce Act (E-SIGN) – and growing expectations from a larger number of citizens and businesses as they embrace the use of the Internet and World Wide Web. Opportunities for additional services abound as new global web technologies are developed and e-government applications become more prominent and widely accepted by citizens and businesses nationwide. Many US State governments have already implemented governmentwide web portals that provide users with links to information and services. For instance, by accessing Virginia's statewide portal (http://www.vipnet.org), residents can quickly connect to a site where they can renew drivers' licenses on-line. Similarly, users can access the Washington state portal (http://access.wa.gov) to link to sites for filing state tax returns electronically. Another 28 states (representing 73 per cent of the US's population) reported having statewide government web portals.

UK has also begun important initiative towards e-government and towards an integration of e-government implementations throughout the country by the launch of e-envoy. e-envoy has been envisioned to cover all public services available online until 2005. The United Kingdom was one of the earliest to launch the

Citizen' Charter in 1991 as part of the reforms process which gave a much larger role to private sector and consumer focus to public services. The United Kingdom Citizens' Charter was re-launched in 1998 with the objective of setting "standards of service" and also involving the citizen in the decision-making process. It sought to empower the citizen to encourage access and promotion of choice by providing him full information. The methodology involves working with other providers of information and service.

The services offered in a one-stop shop should be easily understandable for any citizen or business partner.

The Austrian initiative towards an e-government portal (www.help.gv.at) has become a metaphor for structuring citizen and business information as well as administrative processes in a user-friendly way. This is an excellent example of considering life-events in design where the services offered in a one-stop shop should be easily understandable for any citizen or business partner. The Dutch portal allows citizens to customise the site by postal code, which enables local and regional information to be displayed upon request. Customer relationship management (CRM) in the private sector has benefited companies to maximize their profits by targeting their high-value customers. On the same pattern, government portals can be citizen-focused by implementing citizen relationship management (CRM). There is already general segmentation of government portals along citizens (G2C), businesses (G2B), inter-government (G2G) or civil servants (G2E). Few commendable efforts can be seen by the Canada and Singapore governments where portals have a gateway for non-residents (G2NR) - tourists, immigrants, investors, exporters, and the like. It is prudent to grow portals over the time from simple customer-focusing to deliver more tailored services based on the requirements of citizen groups, such as students, single parents, NGOs, etc.

The European Commission also has funded eGOV project in 2001 that aims at developing an integrated platform for realizing online one-stop government (Wimmer, MA 2002). Key innovations of eGOV are: a global access point to enter different governmental services and information at distinct levels of public administration and with different devices; and the development of online one-stop Government process models. The project is undertaken under a consortium which consists of 10 partners from Austria, Finland, Germany, Greece and Switzerland, reflecting different forms of Government and public administrations throughout Europe. Further, the partners represent a balanced mixture of public and private research institutions, local and global public administrations as well as technology providers. The vision is that the customer decides what kind of device to use to access a certain public service or information. On one hand, this access may happen through the Internet from home, from public kiosks, from service centres or service points spread over populated areas. Here, the global access point is approached via a desktop PC, portable PC or notebook that is connected to the Internet. In some cases, access may even be provided on the move where a portable PC is connected to the Internet through wireless communication facilities (GPRS, UMTS, etc.). On the other hand, certain information, communication or parts of complex services may be accessible on the move independent of space and time. The device used to enter such information and services might be any kind of handheld device (PDAs, mobile phones, etc.). Here, wireless application protocols (WAP) will be the connecting glue to link the customer to the local services and information through the global access point. A distinction is made between three different user groups: citizens, businesses and public administrations themselves. Obviously, businesses have more frequent contact with public authorities (at least once a month) than ordinary citizens. Further, citizens may still prefer to go to a public service point, where a public servant helps them through the administrative tasks s/he has to complete. This is not just due to the fact that, for example, currently, only about 50% of the European population (in the northern part of Europe, the ratio is higher than the mean, whereas in the southern regions it is lower) has access to the Internet. For psychological reasons, citizens will continue to appear personally at the service counter or citizen office in order to consume a public service. Hence, it follows that much of the work burden will fall on the front-office workers that interact with their customers to support them in performing a contact with an authority or act on the citizen's behalf to consume a service. So, one important user group for online one-stop Government applications will be such front-office workers.

In India, the central government has extensively promoted the use of information technology in managing its internal process through the agency of the National Informatics Centre (NIC) which was set up in 1975. A high powered committee constituted under the chairmanship of the Cabinet Secretary took a decision in February 2000 to direct all ministries/departments of the central

A five-year 'IT Vision' and annual 'Action Plans' are also required to be prepared by every ministry/department.

government to designate a senior officer as IT Manager to act as the focal point for promotion of IT. Subsequently, a 12-point 'Minimum Agenda of E-governance' was drawn up, comprising provision of basic infrastructure and training and use of IT for certain G2G operations as well as G2C transactions. A five-year 'IT Vision' and annual 'Action Plans' are also required to be prepared by every ministry/department. A recent review shows that three items of the Minimum Agenda have been implemented by 60% or more of the ministries/departments and another six items have been covered by 20-25% of them. A programme for training/capacity building of IT managers is also being formulated.

The tenth Indian five-year plan has given adequate importance to e-governance. It has conceived the launch of the India Portal (a user-friendly portal of all government websites for providing information and delivery of services), National Institute of e-Governance, Central Repository of Data, Citizen Service Centres for one-stop non-stop delivery of public services, dissemination of information relating to best practices/innovations in e-governance (including a documentary series entitled 'IT in the Service of People'), and awards for best websites and innovative use of IT in the delivery of public services. India Portal is supposed to serve as a one-stop non-stop destination for public access to information on various aspects of government functioning. It is also to serve as a single window for delivery of government services. An Expert Group has already conceptualized its draft report. *Inter alia* it envisages setting up of a National Information Services Board and implementing the Portal with the support of various stakeholders including industry associations, academic institutions etc. It would require development of information management plans, standards, data architecture, reference data, initial data collection and conversion to digital form, forms, deliverables, migration plan, sustainable strategy and maintenance. The critical success factors would be commitment of key contributors, change in work culture, re-engineering of organization processes and e-inventing government. In terms of costing this programme, broadly speaking the hardware, software for data warehousing and developing models of payment gateways for various Central Government organizations and States, and consultancy arrangements for upkeep and maintenance of the Portal will be the minimum requirements. A sum of approximately Rs.100 crore has been recommended during the Tenth Plan for the purpose.

As a major step in bringing in e-governance, NIC has been implementing the following "minimum agenda" of e-governance, as announced by the Central Government:

- G2G - Government -to-Government Portal
- G2B - Government-to-Business Portal
- G2C - Government-to-Citizen Portal: Community Information Centre, AGMARKNET Nodes, Passports, Courts, Central Excise & Customs, Land Records, Property Registration, etc.
- "India-Image" Portal : A G2C Portal to be a state-of-the-art-portal of the Country
- G2G Portal, G2B Portal and G2C Portal in Central Government Departments and its Apex Organizations in the following areas of activities to begin with: Central Excise and Customs, Registrar of Companies, Courts - Supreme Courts, High Courts and District Courts, Passports, Road Transport, Banks and Financial Institution, Agriculture, Water Resources, Women and Child Development, Health and Family Welfare, Rural Development, Higher Educational Institutions, Energy, Industry, Commerce, and Parliament

There are some examples where the state government has provided information relating to various departments online. The examples include the state of Andhra Pradesh, where Chandrababu Naidu had taken many initiatives by launching AP-on-line. There are also some other states that are progressing in the direction of being web-enabled but it will be a few years before it matures.

However, the usage level of the online portal remains a cause for concern. As per the Times News Network (December 31, 2002), the government's efforts to make things easier for the general public, with its value-added e-services, is getting little encouragement. All kinds of forms – from birth certificated to admission forms – can now be found on administrative portals of civic bodies as well as the government. But there are few takers for these services. For instance, the Maharashtra State Electricity Board (MSEB) has now come up with a facility through which it e-mails electricity bills to its consumers. But, as of now, the service has attracted only 10 to 20 customers. There are many reasons behind this lethargy and reluctance to embrace the idea on the part of the users. Firstly, there is little awareness among the masses, given the fact that Netizens still constitute a small percentage of the population. Add to this the fact that administrative websites do not market their people-friendly facilities. General inhibitions as to making payments on a machine and not getting a receipt for it is another factor that discourages people from using the Net. Even regular web users feel comfortable if they get a receipt to rest assured that their payment has been recorded.

Moreover, people are not able to believe the fact that the government can work efficiently online, when it can't even manage to do so offline. Public offices falter in terms of computerisation, seen as the key to e-governance. However, some states, like Andhra Pradesh, have figured out a way to prop up their user base. Apart from its portal, www.aponline.gov.in, it has set up special centres, which offer certificates and receipts. The sites are a relative success thanks to a greater awareness among the people about the facilities available online in the state.

The Kalyan Dombivli Municipal Corporation (KDMC), too, offers over 100 documentation and payment collection services at two of its citizen facilitation centres. The Maharashtra government is also trying to follow in the footsteps with its Setu programme, which already renders about 80 services at a single touchpoint. At Mahanagar Telephone Nigam Limited's billjunction.com, which offers payment facility for telephones, mobile and other bills, each user pays Rs 4 and so does the biller or the utility provider.

Further requirements that have to be fulfilled in an integrated one-stop Government platform are:-

- smoothly adapting traditional processes to modern technology;
- providing access to public services via a single entry point even when these services are actually provided by different departments or authorities (single window);
- enabling access via different media channels and devices (Internet, PDA, WAP, call centres, citizen offices, etc.);
- guaranteeing the necessary level of security, authenticity and privacy in communication and transactions via the Internet, especially for personal data and information that is highly sensitive;
- adapting both the internal (workflow, databases, intranets, etc.) and external (information and communication services to citizens and customers, transactions of goods and services via the Internet) change requests for public activity;
- smoothly coordinating internal and external public activity to facilitate cross-border operations (i.e. seamless Government);
- enabling customers to access public services in terms of 'life-events' or 'business situations' and without knowledge of the functional fragmentation of the respective public authorities;
- allowing customers to approach and monitor different stages of service performance (simple information gathering; interacting with an authority; contracting (online application); service delivery and payment; complaints and other aftercare needs such as feeding statistics or feedback);
- providing customers with pre-information at various stages and in various depths;
- providing help in filling in online forms, etc.;
- clarifying and updating underlying legal issues, laws and prescriptions;
- 'translating' the demand for a service (a license, etc.) from the citizen's/business' world to legal-administrative jargon and vice versa;
- matching online public services with the jurisdictional structure (competency in the legal sense) and routing the citizen demand to the relevant back office;
- keeping track of the process, handling 'freedom of information' requests and other 'due process' requirements (Wimmer, Maria A, 2002).

Obstacles to Counter

One can visualize certain obstacles common to any smart project such as: lack of skill, lack of money, fear, ignorance, lack of imagination, and vested interests. Sometimes, there are people who do not wish to accept any change. If they belong to the top tier in the hierarchy and are capable of influencing decisions, it becomes most damaging as they block progress. These obstacles would be encountered in implementing e-government projects also. There is a risk of e-government systems not matching the purposes of public administrations and there ending up an increase in bureaucracy and a dependence on technology (evidence suggests that IT can increase the amount of paperwork).

Universal connectivity and PC penetration is the most urgent issue to address before we embark upon Government-on-line. The scenario is improving but a comparison with other countries leaves much scope for faster growth in connectivity. Tapan Sidkar, Minister of State for Communications, in November 2000 reported only 380,000 of India's 607,000 villages (63%) provided telephone connectivity ["USO Funds for Rural," 2000]. Second, India's teledensity in May 2002 was approximately 3.94 per hundred individuals, a significant improvement in recent years, but still a low number relative to developed countries. There are

45 countries behind India in the overall telephone subscribers indicators (teledensity) in a 196-country survey conducted by the International Telecom Union (ITU) according to news published in the Indian Express (16 May 2002). 32 of these countries are from sub-Saharan Africa, nine from Asia, three from what ITU refers to as Oceanic countries and one in the Americas. The world average teledensity stands at 32.65 and Asia at 20.07. India's ranking improves to 143rd when looked at from the perspective of basic phone lines with 53 countries behind it so far as normal landline phones are concerned. In the case of cellphones, India has a ranking of 167 with cellphone penetration of 0.56 per 100 people, almost equivalent to Pakistan at 0.55. The world average on this count stands at 15.5 while Asia is at 9.25 per 100 people. Emerging economies like Thailand, China and Malaysia in Aisa and Argentina, Brazil or Mexico in South Africa are way ahead of India in their ranking in overall telecom density as well as personal computers' penetration. As far as PCs are concerned, India ranks 167th in the world for PCs per 100 people with 0.58 PCs per 100 people. The world average for this is 8.42 per 100 people while Asia is at 3.31 per 100 people.

US$69 billion will be needed to raise teledensity to 15% by 2010 [Pai, 2001b]. Although the national telecommunications system is improving, the magnitude of the work yet to be done to provide basic connectivity throughout the nation is such that widespread rural access to the Internet is not likely to be available in the near future. In terms of e-readiness, a recent survey commissioned by a leading US multinational, placed China at the fifth position out of a list of 38 countries. India was a lowly 37. China has an installed base of over 150 land lines and 130 million mobile phones and has overtaken the US in quantitative terms as far as mobiles are concerned. India has just 7 million Internet users while China has 34 million. This means that while 68 Indians in 10,000 have access to the Net, the corresponding figure for China is 260 (Dataquest Monday, March 11, 2002).

In terms of e-readiness, a recent survey commissioned by a leading US multinational, placed China at the fifth position out of a list of 38 countries. India's was a low 37.

There were major differences in e-government performance based on geographic location. In general, countries in North America score the highest, followed by those of Asia, Western Europe, Eastern Europe, Middle East, South America, Central America, the Islands of the Pacific Ocean, Russia and Central Asia, and Africa. However, every region showed gains compared to the previous year. According to a recently released report by the Center for Public Policy at Brown University (West 2002), Taiwan's e-government ranked first among 198 countries, followed by South Korea, Canada, the United States, Chile, and Australia. India ranked 59th in the order of e-government ranking. The Government of India (GoI) had declared 2001 as the 'Year of e-government.' The purported aim was to promote and enhance the use of IT in governance in accordance with the measures suggested by the Task Force set up by the Ministry of Information Technology (MIT) in 1998. But a look at the actual implementation shows that almost 40 per cent of MIT's targets are yet to be achieved and most of them, directly or indirectly, relate to e-government (De 2001). According to Gartner Research, only 10 per cent of the government bodies around the globe will be able to move towards e-government by 2005. India is lagging behind due to poor infrastructure and the slow response to the emerging cyber-culture. The transition from governance to e-government takes place in four phases, beginning with a "presence" phase, followed by "interaction," "transaction" and a final "transformation" phase. India is still in the earliest phases of its transition.

One would accept e-government an evolutionary phenomena. It is not ideally possible to route all public services through a single website because public administration and governance are very complex with a high degree of legal structuring of administrative work, a large amount of non-instrumental rationality and many people and institutions involved. Hence, sometimes governments still have to provide traditional ways for citizens to fulfill their obligations and business with public administrations. The transition to higher level requires careful planning, semantic standardization, intelligent service bundling according to the specific situation and context of a citizen or business partner; the readiness for organizational change and new work responsibilities of public employees; and the adaptation (or creation) of a legal framework to fully enable electronic public service provision.

Resources and funding are another serious and most significant obstacle to e-government. In India of late budget allocations to IT has increased but the spending has not been wise. Budget needs to be guided by a national vision following policy driving well-planned projects. According to Marc Strassman, "Imagination doesn't really cost anything, but it is often in even shorter supply in the public sector than cash". Marc Strassman is President of Citizens United for Excellence in E-Government (www.voxpolitics.com).

Fear of technological change is largely the result of ignorance. Further fear of disclosure capabilities of a fully implemented e-government system is so profound that many in power and bureaucracy would do everything to impede the coming of e-government.

Linked to this mind-set is 'resistance to change' about which Strasman very rightly commented, "a very hard to overcome obstacle to implementing e-government, is residual, irrational, immovable opposition to change, of any kind, justified by any reason, however logical, historically-grounded, plausible, intriguing, promising, and well-argued".

Steps to Nirvana

'Nirvana' means enlightenment. The term was first time coined when prince Sidharth become Budha and attained Nirvana (a sense of gaining eternal liberation in a state of total or super consciousness) in the end after spreading his teachings of the noble path to Nirvana. It recommends a balanced approach to the journey of life towards enlightenment and avoids the extreme of self-torture or self-indulgence. In the domain government, the Nirvana is a one-stop on-line government. How it is achieved requires the understanding of the several issues described above.

Subsequent to this it is important to identify the balance path for government to achieve Nirvana. The first step would be to know the technologies that will enable e-governments such as smart cards, bio informatics, Geographical Informational System (GIS) and wireless technologies. One should be able to evaluate various technologies and recommend the technology for the future. The concept of enterprise modeling may be useful. There are examples of governments bearing the fruits deploying ERP (Enterprise resource planning). This follows aspects of managing data in government enterprises including data warehousing, data mining, decision support systems and knowledge management for government departments to ensure better efficiency and results.

The security threats are enormous in e-governance. It talks about the cyber terrorism and attacks on various websites. Some of the world famous cases on cyber crime can provide good learning. Though the framework of laws related to the Internet like the Indian IT Act 2000 and the privacy laws are in place, there are still many risks. The learnings from the September 11, 2001 attacks on US can act as the benchmark for planning cyber security. A disaster management with a roadmap for the future cannot be overemphasized.

The public-private model in governance brings several benefits as fallout of financial partnership and outsourcing. E-government will demand reforms and reengineering in government for a new government to be more efficient and receptive to the needs of the people. Above all the factors lay the importance of leadership in the success of e-governance projects. Leaders like Chandrababu Naidu, S.M.Krishna and Digvijay Singh have gone a long way in making e-governance successful in the villages of Andhra Pradesh. The role of the CEO and his team are important for the implementation of any successful e-Governance project.

We need also evaluate the performance of an e-government by remaining conscious of the various parameters of success of e-governance projects. International cases help identify the best practices which can be replicated and rolled out in large numbers. The focus should be on gathering insight on challenges in e-governance, new paradigms and value propositions and e-democracy models. The emphasis should be to bring out the reasons as to why some projects have been successful and others have failed.

References

Alter S., Ein-Dor P., Markus M.L., Scott J. and Vessey I. (2001), "Does the Trend Toward E-business Call for Changes in the Fundamental Concepts of Information Systems?" A Debate, Communications of AIS, Volume 5 Article 10 2

Amor, D. (2000) "*The E-business revolution*", Upper Saddle River, NJ: Prentice Hall PTR, p.7

Bartels, A. (2000). "The difference between e-business and e-commerce," Computerworld, Oct. 30

De Rajneesh and Srikanth R.P. (2001), E-government gets going in fits and starts. Available at http://www.expresscomputeronline.com/20011224/focus1.shtml (30 March 2003)

Eckerson, W. (1999c). "Plumtree blossoms: New version fulfills enterprise portal requirements." Boston, MA: Patricia Seybold Group, (June). [online], April 2000. [http://www.plumtree.com/moreinfo/specialo.er.htm].

El Sawy, O. (2001) "Redesigning Enterprise Processes for e-Business, Boston", MA: Irwin McGraw-Hill. p. 7.

Eymeri, J.-M. (2000), The use of information and communication technology in the public administrations of the EU member states, Report of the European Institute of Public Administration, Maastricht.

IBM. (2000) "IBM e-business," viewed at http://www-3.ibm.com/e-business/overview/28212.html on Oct. 22, 2000

Kalakota, R. and Robinson, M. (2001), e-Business 2.0: "Roadmap for Success", Boston, MA: Addison-Wesley.

Laudon, K.C. and J. P. Laudon (2001). "Essentials of Management Information Systems: Organization and Technology in the Networked Enterprise". 4th ed., Upper Saddle River, NJ: Prentice Hall, p. 25

Pai, U.L. (Mar 16, 2001b) "Indian Telecom needs US$69 billion to read 15 per cent Teledensity", India News.

Stolee, C. (2000), "E-Business – Just What Is It?" http://ebusiness.about.com/industry/ebusiness/aa052500a.htm (accessed Oct. 22, 2000.

Shurety, S. (1999) e-business with Net.Commerce, Upper Saddle River, NJ: Prentice Hall PTR, p. 4.

Treese G.W. and Stewart L.C. (1999), "Designing systems for internet commerce", Addison Wesley, Singapore.

USO funds for rural telephony by mid-Dec (Nov 8, 2000) Business Line Internet Edition,

http://www.indiaserver.com/businessline/2000/11/09/stories/14968ru.htm (current Nov 13, 2000).

Wimmer, Maria A. (2002), "A European perspective towards online one-stop government: the government project", Electronic Commerce Research and Applications, p.92-103.

West D.M. (2002), Global e-government, 2002.

Available: http://www.insidepolitics.org/egovt02int.html (30 March 2003).

- http://www.moict.gov.jo/MoICT_Change_Management.aspx
- http://my.execpc.com/~berrestr/broame03.html
- http://www.westerncity.com/June01E-Gov.htm
- http://www.prosci.com/chg9.htm
- http://www.e-government.govt.nz/docs/e-gov-strategy-apr-01/chapter14.html
- http://www.e-government.govt.nz/docs/e-gov-strategy-apr-01/chapter7.html
- http://www.voxpolitics.com/news/voxfpub/story265.shtml

□

Why this reluctance to make the change? We fear the process of reeducation!

– Isaac Asimov

KM in e-Governance

C. S. Arora

Several factors distinguish the functioning of Government organizations from private business enterprises. The importance of Knowledge Management (KM) and its application to e-Governance has been discussed using a 'process perspective' of public administration. The difference in approach for KM implementation in business vis-à-vis e-Governance and the resultant challenges for performance assessment are highlighted. The author then proposes some measures for performance evaluation of e-Governance projects in order to evolve a model for e-Governance performance assessment.

C.S. Arora is director, office of the Registrar General, Ministry of Home Affairs, New Delhi.

The issue of implementing Knowledge Management (KM) concepts in e-Governance raises a number of questions. How different is the relevance and applicability of IT/ KM for e-Governance processes from that in the corporate business environment? What are the challenges for an effective KM-based e-Governance? Is e-Governance aimed at just delivering government services on-line using electronic means or being an instrument for transforming government into an economic engine for stimulating economic competitiveness? Would e-Governance be viewed as provider of citizen information on the web or a provider of comprehensive knowledge required for complex citizen/ business interactions involving two-way knowledge sharing and payments? Are the governments at all levels - central, state and local - adopting e-Governance under pressure to work more efficiently and effectively, or is a fundamental reassessment of their agenda now imperative in all societies globally? How does one measure the outcome of e-Governance in terms of a 'value' framework - rather than being contented with some soft, 'feel-good' benefits?

Understanding these issues is a prerequisite for proper implementation of KM concepts in e-Governance – rather than copying the implementation models of KM in business enterprises. This paper addresses these issues and recommends formulation of a KM-based performance measurement model for e-Governance at the planning phase itself.

The evolving scope of e-Governance

The power that governments wield - as employers, as buyers, as regulators, as a custodian of state defence and public welfare, and as agents for economic growth - is enormous. Passing through the present IT revolution and the associated changes, the impact of this influence takes on new dimensions. Tapscott (1996) has summarized the scenario as follows:

> *"...governments are central players in the new economy. They set the climate for wealth creation. They can act as a deadening hand on change or be a catalyst for creativity. They can*

cause economic stagnation through runaway deficits, or they can set a climate for growth."

As political leaders are being asked to make governments a catalyst for economic growth, they simultaneously face demands to make the services governments provide more accessible, responsive and affordable. Just like the private business sector, governments too now face a need for transforming themselves through a fundamental redefinition of service delivery strategy accompanied by the innovative use of IT. Governments now recognize the value of an improved information infrastructure and see IT as an engine for revolutionizing how they fulfill their basic mission - to deliver health care and education, stimulate economic growth, develop and maintain infrastructure, ensure justice and maintain peace (Thornton, 1997). Addressing these challenges successfully requires them to adopt e-Governance utilizing the transformational power of IT and KM tools. Adopting e-Governance is also a necessity now because in a knowledge-based society put into motion by a hi-tech private business sector, governments can no longer interact in an old fashioned way. Business organizations like to work with government in the same electronic form; they would like to settle regulatory and tax issues on-line and also would like to implement on-line service delivery for all citizens including those processes requiring governmental involvement. Governments have to join the information economy and ofcourse galvanize the economy to higher levels.

The role of IT and associated challenges

Arora (1998) examined the issue of "Does IT matter?" at two levels - at the macro level for the betterment of the societies in developing countries and at the micro level of IT's impact on business enterprises. Though putting in place an effective IT infrastructure has been the basic prerequisite for business survival, it does not automatically ensure business growth and prosperity. Citing various research studies done in Massachusetts Institute of Technology, by Computerworld and elsewhere, Arora has concluded that the limiting factor in transforming organizations is the people's ability to change, not technology. The organizational issues, resistance to change and other change management issues become more pronounced, rather than the IT deployment. He has arrived at the paradigm that "In IT function, the T representing technology is no longer the critical factor for success. The T matters more now if it represents transformation."

The challenges before management while leveraging IT are not technological, but deal with soft dimensions like information culture and resistance to change. Successful IT deployment raises the following three issues surrounding organizational transformation:-

The challenges before management while leveraging IT are not technological, but deal with soft dimensions like information culture and resistance to change.

- When and how to initialize the transformation?
- How to manage the transition?
- How to eventually cope with the change process to ensure its success?

Handling resistance to change and making the organizational culture more conducive to change have emerged as the most critical human-centered challenges, which matters in IT. For efficient handling of this challenge, a thorough understanding of insights into human behaviour and the ability to synthesize the human and technological aspects of change management is required. The mixed results of the implementation of business process reengineering (BPR) for IT-induced organizational transformation are primarily due to varying effectiveness of managers in coping with this human-centered challenge rather than handling technology. What matters in IT is managing transformation, not just technology.

There is lot of commonality on this aspect between business organizations and government departments on the road to effective IT deployment. But there are specific differences too, as given in the following sections.

Difference between the functioning of business enterprises and government

There are several matters that distinguish the functioning of Government organizations from private business enterprises. Even though the initial phase of e-Governance (by way of providing services to the citizens like, granting drivers' licenses, registration of vehicles and properties, etc.) appears to be similar with the services that can be provided by commercial firms, significant differences of a more complex nature do become visible in the manifold activities of public administration. The typical front office operations concerning the interaction of government agencies with citizens form just the tip of the iceberg of e-Governance. Beyond these front office operations, government

functioning covers many processes that are different from the type of processes encountered in retailing, banking or other branches of the economy. Essentially, the difference is to be found at the level of the legal provisions that govern such processes, as well as in the *knowledge* that is required to make the decisions, which are normally the result of the process. Such processes include:-

- Complex decision-making, not only about policy questions but also with regard to operative matters;
- Processes involving negotiations among various stakeholders about matters of public interest;
- Processes of policy formulation (e.g., legislative processes) and democratic participation.

Considering the above administrative processes as unique to the government functioning, the important aspects of difference brought out by Lenk, Traunmuller & Wimmer (2002a) are:-

- The specific tasks of government,
- The role of law
- The special significance of knowledge.

The breadth of government's agenda, especially at the central level includes safeguarding of citizens' life, welfare and defence. Basic goals of government include proper functioning of legislation and jurisdiction, promotion of economic development, protection of principles of civic rights, preservation of environment and emergency management etc. For implementing this agenda set politically, governments have to follow the legal norms as a standard vehicle of communication between government and its stakeholders.

With regard to complex decision-making, knowledge is of particular and special importance to the government. Lenk, et al., have given less importance to those types of knowledge which are required for internal administrative processes, but have brought into focus the other unique types of knowledge which are of relevance to the core business of government. Management of this knowledge assumes special and distinctive significance for e-Governance.

Difference between KM approaches for e-Governance and business environment

Generally Knowledge Management is discussed with regard to business environments where knowledge is of importance for promoting innovation. By contrast, in e-governance, knowledge is considered from the perspective of administrative actions. The special significance of knowledge for administrative decision-making at the operative level makes KM the essential foundation of e-governance. These special types of knowledge to be brought under an effective KM system are:–

- Legal knowledge;
- Knowledge of the facts given in a special case to be decided upon;
- Knowledge about the means of action, which government has at its disposal;
- A repository/ knowledge base of various administrative processes, which is gradually built up while working on a decision case;
- Knowledge about the effectiveness of various performances measures.

Since knowledge like any other scarce resource should be managed, Knowledge Management has become an important issue for e-Governance too. Though KM as a branch of management for managing organizational knowledge and knowledge processes has been well-developed for business environment, no such formal discipline has yet shaped up to consider KM as a distinct activity for e-Governance. What are managed so far are information sources: libraries, archives, and data banks. The ways in which individual decision makers or groups access these sources and interpret the contents so as to transform their own knowledge is in most circumstances not yet seen as something which can be managed.

Knowledge Management has become an important issue for e-Governance.

The knowledge of the decision-makers can be considerably improved if they could command easy access to information repositories of different types in their respective functions. Similarly, another type of knowledge comprising of process history repositories containing both factual and legal information, can be very useful for the decision-makers for interpretation and case-to-case decisions. KM as a formal discipline of management in e-Governance can be very helpful for creation, transfer, documentation, storage and utilization of knowledge comprising administrative processes and decisions, in digital form. This enables the government department to provide required information to citizens and businesses, provide electronic services, create electronic portals and conduct

electronic transactions through integrated systems (Anttiroko 2002).

The conceptual foundation of Knowledge and Knowledge Management

If we are concerned about knowledge management, we need to be clear about what we mean by the word *knowledge* and *knowledge management.* Hence conceptual clarity of these terms is necessary at this stage. A working definition of knowledge as suggested by Davenport and Prusak (1998), is given below:

> *"Knowledge is a fluid mix of framed experience, values, contextual information, expert insight and grounded intuition that provides an environment and framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices and norms."*

From a management perspective, there are clear distinctions between two types of knowledge. Common practice now refers to them as *explicit* and *tacit* knowledge. They can be described as follows:-

- Explicit knowledge is precisely and clearly expressed, with nothing left to implication. Generally, it is fully stated and openly expressed without reservation.
- Tacit knowledge is understood but not clearly expressed. It is often personal knowledge embedded in individual experience and involves intangible factors, such as personal belief, perspective and values.

After knowledge, let's now deal with the other concept – knowledge management. This concept has been debated by academics and managers since long, and so is not new. Business organizations have been practicing it in some way or the other - however informal and unstructured - but only a few businesses have mastered it. Despite this, as a field of systematic study and discipline, KM is definitely new. Many practitioners have come up with a myriad of definitions and often there is little agreement on any one. However one particular definition proposed by the Gartner Group is quite comprehensive and applicable equally for government organizations ("Building Resource Champs", The Economic Times, Sept. 11, 2000). This definition not only tells us what KM is all about, but also emphasizes on what is required for effective KM, and more specifically what it can do or not do.

> "KM is an emerging set of processes, organizational structures, applications, and technologies that aim to leverage the ability of capable, responsible, autonomous individuals to act quickly and effectively. KM achieves this end by providing this capable, responsible, autonomous individual with ready access to the company's entire store of knowledge, including much of what is not documented. KM requires an integrated approach to identifying, managing, and – most importantly – sharing the company's information assets, including database, documents, policies and procedures (explicit knowledge) as well as undocumented expertise resident in individual workers (tacit knowledge)."

The "process perspective" binding Knowledge Management with e-Governance

The comprehensive definition of KM given above is based on a framework for consideration of KM as the "set of processes" by which knowledge is manipulated in an organization. The set of processes comprising the KM programme in an organization is as follows:

- Knowledge creation: To discover, realise, conclude, articulate and discuss for creating new knowledge
- Knowledge capture: Includes documenting, digitizing, extraction, representation and storage of relevant knowledge
- Organizing knowledge: Structuring, cataloging, abstracting, analyzing and categorizing of knowledge for specific usage
- Knowledge access: Presentation, display, notification, profiling and searching the knowledge for a specific application
- Knowledge application or use: Includes application of knowledge for business performance, providing service, making new products and continual learning at organizational level.

Source: KM Architecture and Technology, Presentation at Gartner Group Symposium, Florida (1999).

The set of KM processes primarily involves people. Thus, KM activities are fundamentally linked with collaboration, interaction with people, and the systems which support this. The technology plays an enabling role for KM processes, for example, use of an Intranet facilitates collaboration and interaction among people, but it is finally the human dimension that plays a driving role for KM processes.

A similar paradigm of viewing e-Governance as a "set of administrative processes" can be visualised. Lenk, et al. (2000b) have developed a process model for public administration combining the two perspectives of processes seen as production processes and decision-making processes. While the production processes are somewhat similar to the traditional business processes

in commercial organizations, the administrative decision making processes are somewhat different for e-Governance, which involve negotiation processes and democratic deliberations for policy making.

The use of knowledge and associated KM system depends upon the type of e-Governance processes. This process perspective binds KM with e-Governance as given in Table 1 below:

Table 1: Linking KM with e-Governance Processes

Administrative process type	Issues in Knowledge Management
Routine processes	Knowledge of citizen information
Individualised decision-making	Knowledge of law and process repository
Negotiations	Knowledge-enhancing platforms for group decision making
Democratic deliberation	Basic civic information/ structuring debates

For each of the above administrative processes, a different KM system has to be developed. Basically it involves a mapping exercise of administrative processes with corresponding KM processes. The routine processes of recurrent production nature can be benefited to some extent from the standard procedure of customer relationship management (CRM). But there are additional exigencies in the government processes concerning identification of the parties, security and reliability of the communication, etc. However broadly, these well-structured processes of citizen-government interactions are well amenable to KM processes. Similarly, for individualised decision-making, a process repository with legal knowledge embedded can be given by a suitably designed KM system. However, for other processes like negotiations and democratic deliberations, effective KM systems are still to be developed specifically for e-Governance. The existing tools like group decision support systems (GDSS) can perhaps provide a starting base for such development.

Performance measures for KM-based e-Governance: the challenges

According to a latest report by Gartner Group on e-Governance, more than 50% of e-Governance projects worldwide will fail to deliver the service levels required by citizens and businesses. Obviously, the intangible, 'feel-good' factors like improved quality of citizen services, better law enforcement, increased transparency, increased convenience, higher efficiency, etc. would not deliver the real business value. These 'feel-good' factors sound very promising at the initial stages of planning, but unless a rigorous model for performance metrics is in-built through the entire cycle of e-Governance planning till implementation, disillusionment is bound to set in. According to this report released in June 2003, Indian e-Governance initiatives have reached the 'peak of inflated expectations', and through 2003 till 2005, a 'trough of disillusionment' would be faced on the 'hype cycle' of e-Governance. A major reason is the lack of rigorous performance measures for the initial projects of e-Governance started in the last 2-3 years. Only after this challenge of putting in place a practical framework/ model for performance assessment is addressed, would the 'business value' be added to these projects. Gartner expects a 'period of enlightenment' for e-Governance projects in India from 2005 to 2010, followed by a 'plateau of productivity'.

Neely (2002) talks about the practical challenges in design and implementation of performance measurement systems. Different challenges are associated with four fundamental processes of performance measurement: measurement system design, implementation, managing through measurement, and 'refreshing' the measurement system. In design, the challenge lies in choosing the right and vital measures and avoiding *excessive* measurement. At the implementation stage, the challenges are two-fold. There is the data access issue, i.e. the need to get access to the right data, and the political and cultural issues, notably people's fear of measurement and the games they consequently play to try to manipulate target setting. To combat this, people inside organizations need to be educated to understand the purpose and use of the measurement system.

The challenges for formulation of performance measures for KM-based e-Governance can be coped with successfully only if some common pitfalls are avoided. Tiwana (2000) reports that most organizations are vulnerable to the following pitfalls in their choice of KM-based performance metrics:-

- Using too many metrics
- Delayed and risky rewards tied to metrics
- Choosing metrics hard to control
- Choosing metrics hard to focus on
- Choosing metrics that neglect the "soft results" or intangible outcomes
- Choosing metrics that are too rear-view oriented
- Measuring the wrong things

Skyrme (2001) has dwelt in detail about the practical

considerations for formulation of new metrics for KM-based activities, which are directly relevant for the performance metrics for KM based e-Governance. These are:-

- The organization's strategic objectives, business priorities, and critical success factors should be the starting point for determining the categories of performance measures and organization-wide indicators.
- The indicators chosen should reflect a mix of different types, such as inputs, processes and outputs, absolute numbers, ratio, percentages, and subjective ratings.
- Develop indicators with a future orientation, that is, lead indicators of financial performance.
- Have enough, but not too many, indicators in each category (typically two to four, giving around 12-15 key indicators in total).
- Develop causal loop models that help you understand the interdependencies.
- Develop indicators as a team process, so that people are sharing knowledge and coming to a common understanding of the organization.
- Allow a degree of customization across organizational units, but have some common ones to aid comparisons.
- Align individual goals and metrics with those of the organization's measurement system.

Proposed performance measures for KM-based e-Governance

The need for an effective framework of performance measures for KM-based e-Governance has been very clearly brought out in the above section. The challenges associated with formulation of new metrics for performance of KM-based activities like e-Governance have also been spelt out, along with some practical guidelines for formulation of new metrics. Further research is recommended in this direction, because there are no available models for implementation on 'off-the-shelf' basis. This is mostly because e-Governance is rather a recent activity - particularly in India. Additionally, the existing research in potentially relevant fields in the business domain (such as data processing or management information systems) does not incorporate the views, concepts and history applicable to e-Governance. As an illustration already given, the goals of e-Governance include not only more efficient operations (as in the business environment), but also better quality of service, and increased and better quality of citizen and business participation in governance processes.

The starting point for such research would be the identification of various potential measures for performance. The performance measures for KM-based e-Governance would expectedly be different from the measures for KM-based business enterprises. Some of the potential performance measures for e-Governance are proposed below. These are however to be taken only as starting reference for further research into the relative importance and the measurement/quantification ease for each of these factors. Only after the initial field research using certain rigorous survey instruments, the stronger of these candidate factors should be short-listed for further analysis of their impacts on the e-Governance performance. It is expected that such a research by the government departments at the central or state level would lead to a performance framework comprising of around 12-15 key measures in 2-4 broad categories. The initial measures proposed for performance evaluation of e-Governance projects are as follows:-

- IT infrastructure investments
- Investment on communications infrastructure
- Return on Investment (cost savings, increased revenue) from e-Governance projects
- Duration of functioning of e-Governance projects in that department
- New users (citizens/ business entities) registered in a period
- Average number of times a registered user has used the system
- Ratio of repeat users to the total users in a period
- User satisfaction (on a measurable index)
- Servicing employee satisfaction (on a measurable index)
- Average training imparted to servicing employees (in days)
- Specific training on KM based e-Governance imparted to employees (in days)
- Total spending on training/competence development for employees
- Ratio of staff dedicated for e-Governance to the total staff
- Availability of a documented e-Governance 'vision' for that department

- Extent of integration of e-Governance with policy objectives
- 'Image' of that government department (on a suitably calibrated scale)
- Change in corruption level (measured on a suitable index), etc.

As explained already, the above-proposed factors are just indicative as a starting base for further research. These are not obviously exhaustive and some of these are not directly measurable. Further research has to cover determining the extent/ease of quantification and the degree of importance for each of these factors, before being incorporated into a structured model/ framework for e-Governance performance.

Concluding remarks

The concepts of Knowledge Management have been applied so far generally to business organizations. The design, implementation and management aspects of KM have been streamlined quite adequately for large business enterprises – particularly in service sectors like consulting and finance. However the assessment of effectiveness of KM in business enterprises is still a subject of advanced field research presently – even though some leading global corporations have formulated their own KM assessment frameworks (which they have not shared yet in public domain).

The concept of e-Governance has been gaining ground recently, from initial isolated attempts of application in the US and European Union, to extensive application and research in developing countries - particularly in India. Emerging from the practitioners' domain, e-Governance has now added serious research, implementation and policy framing issues to its agenda. This is because emerging from automation of just the front office operations of electronic service delivery, e-Governance is progressing onwards to increased and better quality citizen participation through enhanced collaborative systems and a knowledge-based model leading to a *transformation* of government functioning. The relevance of KM in e-Governance and the differences in concepts and implementation of KM programmes from those in business organizations have been becoming clearer. However, like in the case of business enterprises, performance measurement for KM-based e-Governance is one major implementation challenge, that requires even more serious research for evolving a structured model for result assessment.

The difference in approach for KM implementation in business vis-à-vis e-Governance and the resultant challenges for performance measurements highlighted in this paper are more of a practical nature and are not abstract. Work has to go into researching for relevance and quantification of some factors proposed. It is only after a formal structured framework is evolved through extensive research that the decision-makers for e-Governance projects can be confident of the real business value of these projects.

References

Anttiroiko, Ari-Veikko (2002), "Strategic Knowledge Management in Local Government, in Gronlund, A, Electronic Government: design, application and management", (pp. 268-298) Idea Group Publishing, Hershey, PA.

Davenport & Prusak (1998) "Working Knowledge: How Organizations Manage What They Know", Harvard Business School Press, Boston.

Lenk, Traunmuller & Wimmer (2002), "The Significance of Law and Knowledge for Electronic Government, in Gronlund, A, Electronic Government: design, application and management", (pp. 61-77) Idea Group Publishing, Hershey, PA.

Neely, Andy, Spotlight on Andy Neely, (2002), "Emerald Now, management learning into practice", http://www.emeraldinsight.com/now/spotlight.htm, March.

Skyrme, David J, (2001) "New Metrics: Does It All Add Up?, in Despres & Chauvel, Knowledge Horizon: The Present and the Promise of Knowledge Management", Butterworth Heinemann.

Tapscott, Donald (1996) "The Digital Economy", McGraw Hill, New York

Thornton, Kenneth R. (1997) "Rethinking Government", IBM Corporation, Washington, DC.

Tiwana, Amrit (2000), "The Knowledge Management Toolkit: Practical Techniques for Building a Knowledge Management System", Pearson Education.

□

The worse the news, the more effort should go into communicating it.

– Andrew S. Grove

Green Supply Chain Management: A KM Focused e-Governance View for SMEs

S. Wadhwa, Avneet Saxena & Anil Kumar

This paper examines the significance of Knowledge Management (KM) focused e-Governance in the Green Supply Chain Management (GSCM) context and discusses a few innovative ideas in this direction. In our opinion, the KM-focused GSCM simulator can encourage small and medium entrerprises (SMEs) to become effective green movement partners in the supply chains.

S. Wadhwa is Professor; Avneet Saxena and Anil Kumar are research scholars at Indian Institute of Technology, New Delhi.

In order to achieve a sustainable economic system, industries must improve their Green Productivity (GP), which is defined as "a strategy for enhancing productivity and environmental performance for overall socio-economic development" (APO, 1999). The goal of GP is to achieve improvements in productivity, quality and sustainability. GP designers need to consider not only stand-alone enterprises, but also the supply chain management. In our view the vision of green productivity can be augmented by popularizing the impact of every decision in any existing supply chain on the environment parameters (i.e. greening the supply chains). Here IT and Government can play a significant role. In this direction Knowledge Management (KM) focused e-Governance can offer significant GP benefits, especially to the small and medium enterprises (SMEs) in the supply chain.

Is simple business sense, Knowledge Management (KM) can be seen as creation, sharing, adaptation, application and advancement of knowledge in enterprises to improve their performance. Tiwana (2000) views KM as the ability to create and retain greater value from core business competencies. A number of multinationals are using existing and new knowledge for moving to green their supply chains, and purchasing policies are reflecting the environmental requirements. To stay in the market, suppliers also need environment-focused knowledge and have to modify their business practices. Thus research direction in the area of green manufacturing has extended into green supply chain management (GSCM). GP and GSCM have synergies and provide organizations with a means to enhance their productivity quality, and improve the environmental performance (Lamming and Hampson, 1996). According to Gilbert (2001), greening the supply chain is the process of incorporating environmental criteria or concerns into organizational purchasing decisions and long-term relationships with suppliers. Greening of the supply chain by organizations is forcing both upstream and downstream parts in the supply chain to re-examine

their business practices. The GP-GSCM practices have focused on reduction of waste and re-use of products (e.g. reverse logistics etc). There is a need to enrich the integration strategies in supply chains with a focus on transportation and distribution systems. This area deserves greater research attention, especially for SMEs in the global context. In this paper we attempt to demonstrate the need for this focus.

Greening of the supply chain by organizations is forcing both upstream and downstream parts in the supply chain to re-examine their business practices.

There is also the governance issue on the supply chain that could facilitate enhancing environmental performance through a supply chain. To control various environmental laws, governance system need to use IT effectively (Humphrey and Schmitz, 2001). The Government is a knowledge intensive institution, which possesses tons of data on citizens, businesses, rules, procedures, precedents and paper files. There is a need for a good amount of planning for the management and distribution of knowledge that spans areas of projects, domain experience, and other knowledge bases. In this context, e-governance can ensure more web-based services that can help GSCM managers to follow environment knowledge by accessing the Government knowledge bases. In our opinion, the GSCM managers must also evolve knowledge-focused decisions that may reduce the distribution and transportation costs. This paper examines the significance of such KM focused e-Governance in the GSCM context and discusses some innovative ideas.

Despite the importance of GSCM in industrial ecology, the integration of logistics flow in a green supply chain still remains a critical issue in GSCM for the organizational strategic point of view (HWA, 2001). Furthermore, the corresponding member behaviour, e.g., the willingness to supply products within time, and other external factors such as government policies and regulations, influence the performance of a green supply chain (GSC), particularly in the transportation and distribution channels which critically impact the environment. We explicitly demonstrate the transportation based demo model that shows how the distribution decision affects the entire chain.

Global Supply Chain Management Overview

The synergy of GP and GSCM provides an opportunity to assist organizations, to enhance their productivity, quality and environmental performance through the continuous flow of information, technical assistance and support, and sharing of knowledge. GSCM is a modern management mode of synchronizing the thoughts about environment protection. For instance the product life cycle assessment focus is increasing. This means more knowledge sharing on the processes of the raw materials procurement, the design and manufacturing, distribution and transportation, usage, recycling and reuse are considered systematically. According to Sarkis (2003) business organizations are facing increasing pressure of balancing marketing and environmental (green) performance. In the same way Gradel and Allenby (1995) highlight the current state and trend of environmental degradation (from regulatory, consumer, and moral standpoints), from enterprise to enterprise integration. This indicates a need for a change in the environment-based enterprises philosophy. The new logic on competition is based on supply chain (Stock, 1998), and new trends in the market can help to implement the green supply chain. It is important to analyse the productivity issues in supply chains that are becoming global. Wadhwa (2004) attempts to investigate global SCM implications on total productivity improvement and indicates that knowledge sharing focused decision making in global chains can result in higher productivity. There is a need to extend such studies towards GSCM contexts. Compared with the traditional supply chain, GSC has some different characteristics like green, closed loop of material flow and integration. GSC emphasizes the environmental characteristics of the supply chain requiring the minimum consumption of resources and energy and environmental pollution. This is obtained based on the green performance of the parts of the supply chain with suggested alternative methods. The traditional supply chain is an opened-loop process that ranges from raw materials to the usage of the products (Khoo et al. 2001).

Figure 1 explicitly shows the directional paradigm shift towards GSCM. We have considered the evolution of the environment consciousness from single enterprise to extended future level GSCM. Initially, environmental (green) consciousness developed due to the realisation of environmental impacts. Now it has become a necessity to follow the environmental rules, regulation or in short environmental (green) culture to compete with various governments, businesses and global needs.

Enterprises have developed a diverse set of initiatives for greening SCM, including screening suppliers for environmental performance, providing training to build supplier environmental management capacity, and

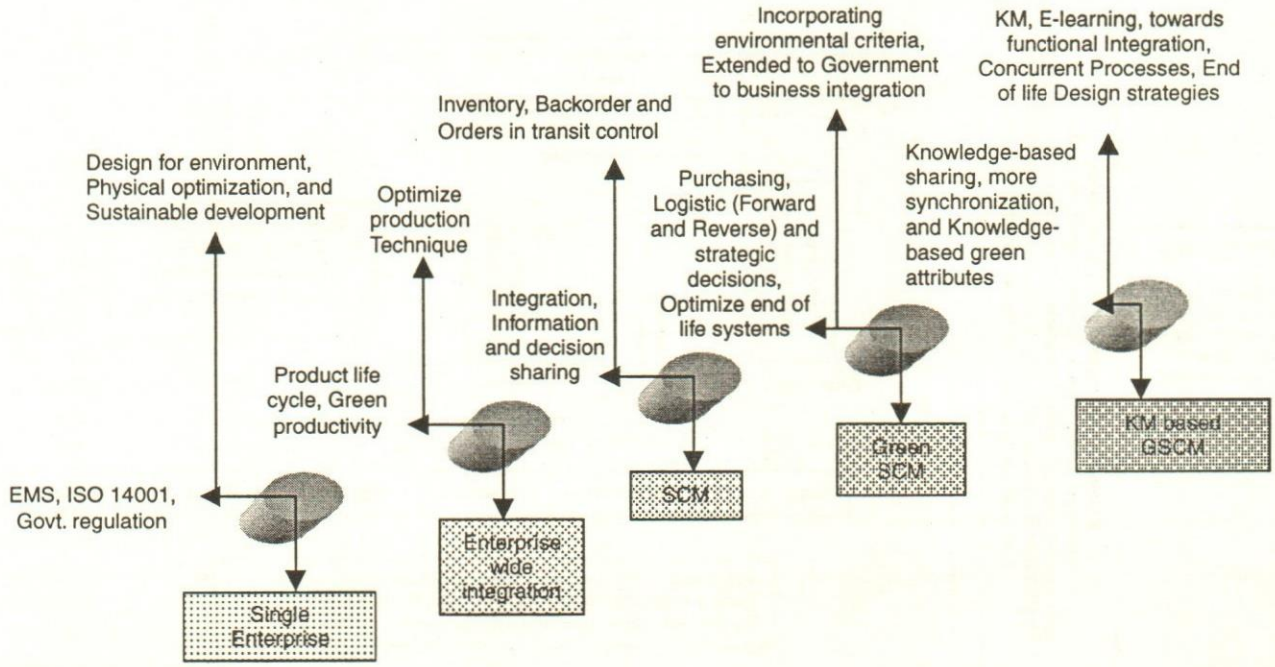


Fig. 1.

developing reverse logistics systems to recover products and packaging for re-use and remanufacture. Green SCM cannot only generate environmental benefits, but also business benefits (Beamon and Fernandes, 1998). However, a major challenge in industry is the transition from the conventional supply chain to a green supply chain. Due to several constraints this transition could imply use of several supply chain routes towards greener directions. A supply chain may have several supplier options, several transportation options, several ordering and several supply quantity options. This implies that the transition phase may need to focus more on operating with SCM flexibility. Wadhwa and Rao (2003, 2004) discuss how supply chains can exploit SCM flexibility to their advantage. In our opinion, the concepts can be applied to GSCM too. Wadhwa et al. (2002) shows the role of structural flexibility and how simulators can help to innovate effective e-business structures. They also highlight the role of flexibility in the supply chains using demo models. One may need good simulation models to help exploit the underlying flexibility towards improved GSCM performance also. For instance, a simulation model may depict the importance of choosing the right option on transportation mode in a GSCM network. This may ultimately affect the environment because the entire transport mode may be using a fuel that is less hazardous to the environment. At the same time, the simulation model may show that it also reduces overall costs etc. In short, greening of supply chains may be facilitated by a total systems focus and tools such as simulators may help in re-engineering the existing supply chains. Government can play an important role by sharing knowledge, influencing consumption patterns, encouraging suitable demand profiles, providing subsidies on greener fuel-based transport systems and in inspiring management of environment knowledge across various firms of supply chain systems.

KM-based E-Governance

As a concept, e-Governance can be perceived to be contextually inclusive of e-Business based processes in organizations (Okot-Uma, 2001). Government systems can maintain on the web environment related knowledge that is useful for Industry. Effective KM practices can help to share this knowledge with GSCM members on needs basis. Continual efforts to grow awareness, acquire, adapt, apply and advance environment-focused knowledge may be carried out. The development in e-governance requires a rethinking of knowledge distribution as it significantly affects the organizations and the supply chains. The e-governance framework can integrate localized knowledge sources into a single integrated system and serve as one stop for governance (Gupta et al., 2003). KM can facilitate the government to share knowledge in an industry – government integration environment, which can further provide a guide to follow the environmental (e.g. green) regulations effectively. Figure 2 elaborates governance and environmental needs with a new supporting KM-based paradigm. This shows that the various environmental attributes play an important role in government – industry integration. Knowledge Management (KM) is

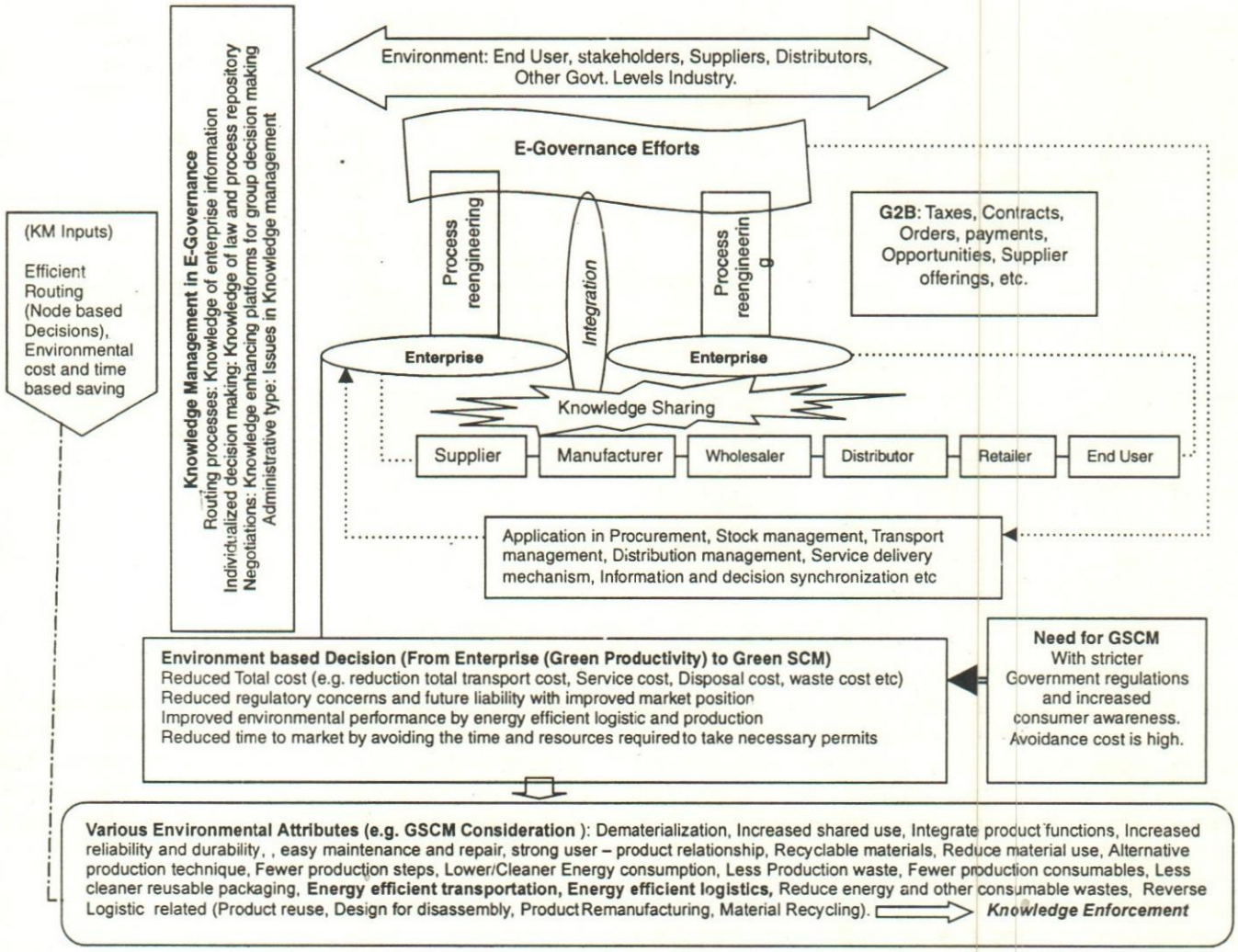


Fig. 2.

also foreseen as a vital application area in this domain by encouraging knowledge sharing with various GSCM nodes.

KM as a formal discipline of management in e-governance can be very helpful for creation, transfer, documentation, storage and utilization of knowledge comprising administrative process and decisions, in a digital form. This enables government departments to provide the required knowledge to citizens and businesses, provide electronic services, create electronic portals and conduct electronic transactions through integrated systems. KM provides processes to capture a part of tacit knowledge through informal methods and pointers and high percentage of explicit knowledge, reducing the loss of organizational knowledge (Nonaka and Takeuchi, 1995). A KM based e-Governance can be promoted towards sharing of both explicit and implicit knowledge by developing collaborative work groups focusing on environment impact issues. E-government may involve several autonomous bodies that facilitate government to business relationships (G2B). In this manner, the businesses as part of supply chains may have easy access to environment impact data leading to an easier road towards GSCM.

E-Governance and GSCM

E-governance can play a vital role in GSCM by focusing on environment through the business to government (B2G) and government to business (G2B) processes. These processes mainly encompass procurement, distribution and supply chain interaction decisions. E-governance can thus facilitate greater environmental concern for cleaner production, cleaner society, visibility to government regulations, future liability, opportunities for waste reduction, landfill or disposal of product etc. E-governance can facilitate various environmental tools like Environmental management system (EMS), ISO 14001, and Design for environment

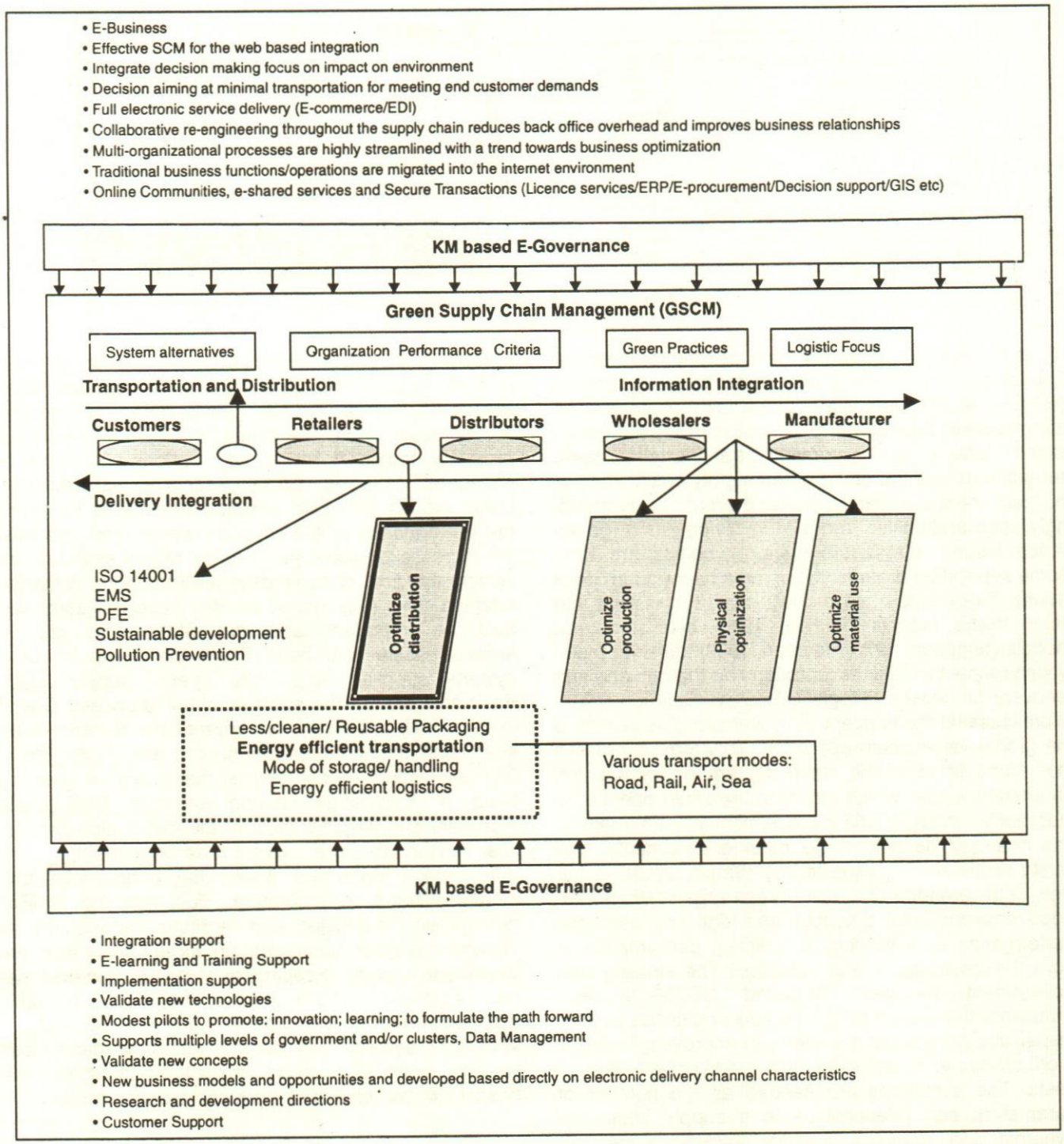


Fig. 3. Detailed Schematic for Application of KM based e-governance in Green Supply Chain Management

(DFE). These evolving phenomenon can facilitate government to post environment related knowledge and regulations for the use of GSCM firms. As a concept and an emerging practice, e-governance seeks to realize processes and structures for harnessing the potentialities of IT and environmental consciousness at various levels of government and beyond (Wadhwa and Saxena, 2003). The real benefits of this will be achieved if the existing government processes are carefully re-engineered. Figure 3 shows a suggested schematic of e-governance and global supply chain integration.

GSCM is an area in which the government must support greater R&D and must encourage re-engineer-

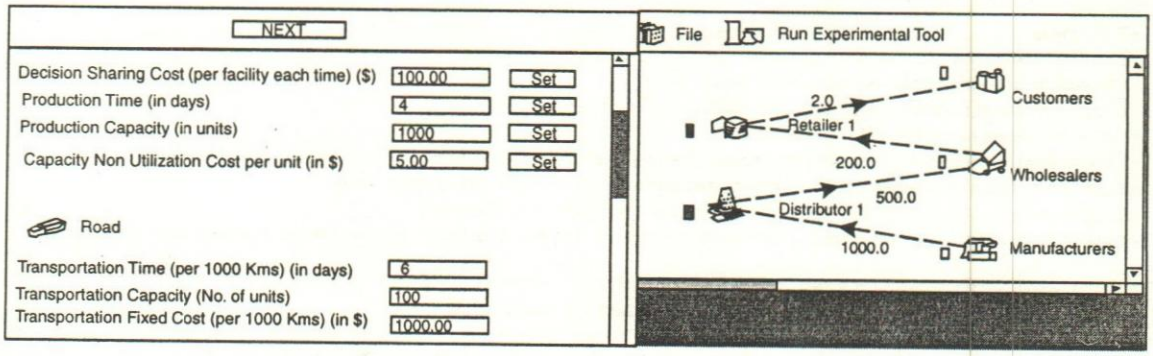


Fig. 4. Simulation Tools used to analyse GSCM

ing of the existing production and distribution process. Transportation is one key area that now needs greater government attention. We depict a few governance related issues in this regard. Our focus is to expose governance issues in systematic transportation-based decisions across the entire green supply chain which in the past were the least noticeable areas. Correspondingly, comprehensive models involving such governance issues across green-supply chains are rare. Some supportive arguments can also be found in Stock (1998). These published models can be classified into deterministic models (Richter, 1996) and stochastic models (Simpson, 1978; Heyman, 1997), differing mainly with respect to their assumptions on the demand and recovery processes of logistical flows. Beamon (1998) expresses that the concept of "governance" is central to the global value chain approach. This term expresses that some firms in the chain set and/or enforce the parameters under which others in the chain operate. In automotive industry, the development of new material has emerged as a trend to meet environmental and safety requirements, as noted by (Sarkis, 2003). In our view, e-governance can make green organizations with good environmental practices and high environmental performance as a strategy to efficient performance of both the government and industry. The industry and government requires KM-based GSCM focused simulators that can highlight the role of logistics system (especially the transport system) in improving both the productivity and reducing the environment impact costs. The simulators are needed as the number of parameters and relationships in a supply chain are dynamic and complex. Intuitive thinking alone can prove to be counter-productive.

Simulation Modeling of GSCM: A Tool for SMEs

Considering the existing models for integrated logistics management in a green supply chain, this study demonstrates the role of KM-based simulators for GSCM. Here, an integrated logistics control model is formulated to systematically minimize the net cost and to reduce transport impacts of logistics flows across a given chain comprising of several autonomous SMEs. The simulator allows to model appropriate transport mode and options. Environment impact-related costs can be associated with transportation modes. We also simulate the model to check the performance in the situation where time and cost will increase by some percentage. Model extension involving the goal of minimizing environmental pollution-oriented risks (e.g. based on distribution system) can also be important and the SMEs can play a knowledgeable role here. From the viewpoint of a system supplier, (e.g., the green supply chain decision makers), the success of the proposed GSCM system may also rely on appropriate transportation strategies, lead-time of the supply and cycle times. Our simulation model shows that there is growing need of knowledge sharing amongst SME chain members and larger players in the distribution processes. Although the major decision-makers are autonomous SMEs and others, they cannot work efficiently without collaboration. For instance SMEs–government interaction can facilitate the industry to choose the best transportation mode (with less environment impact). Keeping in view the dynamic nature of various systems, even a choice on alternative distribution modes can lead to significant GP and environment benefits. For demonstration of these ideas we now describe a sample simulation that highlights a typical KM based GSCM business process model.

The Business Process Model

The business process model used for demonstration purpose simulates a four-link productions/marketing chain comprising of a group of factories, a group of distributors, a group of wholesalers and a group of retailers (Figure 4). The SMEs and other members of the chain order products from the upstream facility receive orders from the downstream facilities. The model simu-

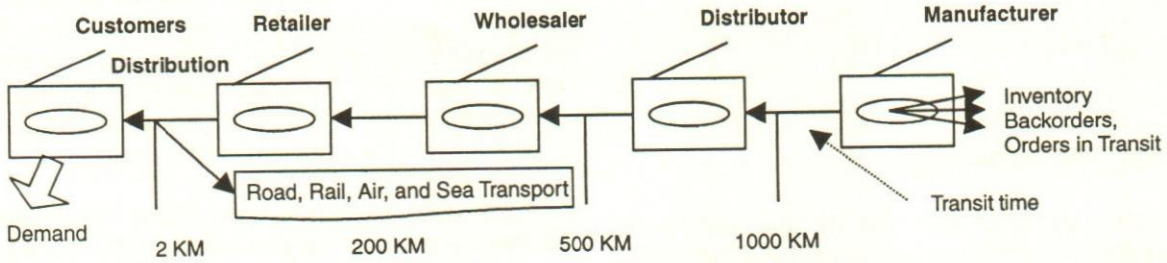


Fig. 5.

lates the system dynamics in a supply chain system. The model is extended from Beer Game developed at MIT (MIT Beer Game, 2003). Our model is more flexible and employs environment costs related to transport choice, but the basic structure remains the same viz. the participants send product orders up the supply chain, and push products down the supply chain. Further we treat the SMEs as having a greater flexibility on the decisions and choice to be a part of a given GSCM.

Material flow/logistics Model

Material flow models represent physical material flows of parts/products from suppliers to customers. A typical four-level model contains factory, distributor, wholesaler and retailer levels. Logistics models deal primarily with material flows at the various levels. It is at these levels that the transfer of materials is accomplished using some sort of transportation such as trucks, train, boat or plane. The logistics model includes order planning, transportation planning, and inventory planning, among others. Material flows in the supply chain are handled by the transportation systems, which in turn are governed by some time-cost trade offs. The following four main types of transportation modes are considered 1) Road Transport 2) Rail Transport, 3) Air Transport and 4) Sea Transport with the following parameters:

- Speed / Transportation time per unit distance (S) $S_1 < S_4 < S_2 < S_3$ ...(1)

This relation holds as road transport takes highest amount of time and air transport is the swiftest. Hence, road transport has the highest pipeline cost.

- Transportation capacity (K) $K_1 < K_3 < K_4 < K_2$ ...(2)

A truck for example has a capacity to carry a maximum of 100 units of a product. This parameter depends on physical constraints of the carrier.

- Transportation fixed cost (Cf) $Cf_3 = Cf_2 < Cf_1 < Cf_4$..... ...(3)

The transport agency will charge this fixed cost for each transport project depending on the distance of transport.

- Transportation variable cost (Cv) $Cv_1 < Cv_4 < Cv_2 < Cv_3$... ...(4)

This cost varies with the number of items to be delivered. The transport agency will also take into account the distance of transport.

- Total Transport Cost $TC = Cf + Cv + Cp$ ...(5)

Cp is the pipeline cost that the sender bears. The total cost can be calculated once we have the distance of the destination and the number of items to be delivered.

Distribution Planning

A major impact on the cost is due to the choice of the transportation mode made for transporting the product to the customer. The decision parameters are: Transportation time (lowest for air transport), Pipeline cost (lowest for air transport), Fixed cost (lowest for air transport), Variable cost (lowest for road transport), Transport capacity (highest for rail transport), environmental cost (lowest for rail transport).

Costing Model

Each player incurs certain costs on each working day of 40 seconds in the simulator.

Inventory holding cost (I) is viewed as: if 'N' is the number of items in the inventory and 'IPD' be the cost of keeping 1 item for a day, $I = N * IPD$ ...(6)

Backlog cost (B) is seen as: if 'M' be the number of items in backlog and 'BPD' be the cost of backlog of 1 item for a day, $B = M * BPD$ ...(7)

Transportation cost (T) is the sum of all the transportation cost for the day.

$$T = \Sigma TC_i \text{ for all i on that day} \quad \ldots(8)$$

$$\text{Total Cost (CT) at jth day } CT_j = CT_{-1} + (I + B + T)_j \quad \ldots(9)$$

Results and Discussion

We have considered the case of one product (P) that is supplied in unlimited numbers by factory, distributor, warehouse and retailer to customers (demand creator). Some of these are treated as SMEs with respect to their limited capacity and lead times to meet sudden higher demands. We consider a simple linear supply chain to reduce the complexity but the simulation modeler has the capability to develop models for more complex cases like two stages or three-stage, full flexible supply chain. The linear GSCM mean that all the members of a supply chain can order the product from his upstream member and supply it to the downstream members (figure 5). The SMEs are capable of supplying different quantities of the product with different lead-times. There can be overlaps in cost/quantity/lead-time combinations over several ranges of values. These parameters effect the distribution-based environmental decisions. The associated cost and time structure is given in the environmental summary. The system is able to choose the most appropriate distribution mode for any combination. This will not vary with the distance, lead-time and effects of variable demands. Our focus is transportation-based decision, so we ignored other supply chain-based results.

In our distribution channel (comprising of many autonomous SMEs), we compare the performance of the various transportation modes by simulation. We evaluate the performance based on - cost incurred per item delivered and average transit time in days. In our model, we have given ten small increments to transit cost and transport time. Each time we measure the performance factor and finally summarize the results. We found that the decision varies in dynamic environment if we want to consider the green supply chain. We cannot stick to minimum cost or time-based transport. We have to choose our transport on real time basis. To decide the least cost/ time-based transport to minimize the aggregate cost of the system, we used cost-based performance measure, which minimizes the overall cycle time. We have evaluated the effect of the cost incurred per item delivered which is the total cost incurred by the supply chain (apart from production cost) in delivering one item from factory to customer. Initially we set some default values of all the parameters and run the simulation for each case and compare the result for least cost transportation mode, that we have generated in the simulation model. Table 1 provides the SC simulation environment information for Linear GSCM including two factories, two distributors, two wholesalers and two retailers, linked with higher-level SC node in the hierarchy of entire SC. They can supply quantities within a given lead time range and the corresponding unit cost. Figure 6 shows a sample demand pattern.

This data gives the details about the simulation environment in which the simulation model is working. The default demand considers 500 items, which remain constant, and hikes take place only once after 15 days (up to 2000) and then for the remaining period follow the usual pattern of demand (i.e. 500). The other parameters show the default value, which is selected to run the simulation considering imitation of actual working model. The environment summary gives the transportation mode and selection of appropriate transport, which may be by Road, Train, Airplane and Sea.

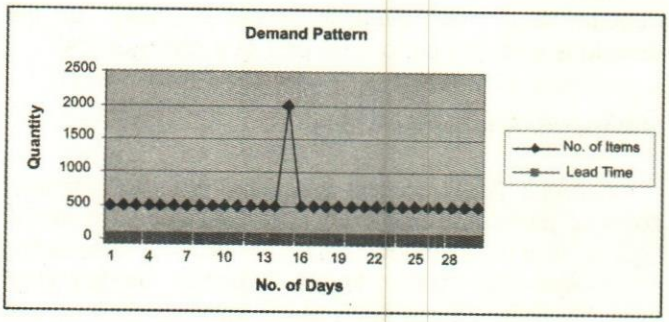


Fig. 6. Customer Order Demand Pattern

The detail environment summary:
Initial Inventory = 2000
Order Delay (in days) = 0
Inventory Cost per unit (in $) = 3.00
Backorder Cost per unit (in $) = 5.00
Ordering Cost for zero Lead time (per order) (in $) = 250.00
Lead Time for which zero Ordering Cost (in days) = 10
Decision Sharing Cost (per facility each time) ($) = 100.00
Production Time (in days) = 2
Production Capacity (in units) = 4000
Capacity Non Utilization Cost per unit (in $) = 5.00

Road

Transportation Time (per 1000 Kms) (in days) = 4
Transportation Capacity (No. of units) = 1000
Transportation Fixed Cost (per 1000 Kms) (in $) = 1000.00
Transp. Var. Cost per unit (per 1000 Kms) (in $) = 10.00, Environ. (Green) Cost 10% of total cost

Rail

Transportation Time (per 1000 Kms) (in days) = 2
Transportation Capacity (No. of units) = 4000
Transportation Fixed Cost (per 1000 Kms) (in $) = 0.00
Transp. Var. Cost per unit (per 1000 Kms) (in $) = 35.00, Environment Cost 2% of total cost

Air

Transportation Time (per 1000 Kms) (in days) = 1

Transportation Capacity (No. of units) = 1500

Transportation Fixed Cost (per 1000 Kms) (in $) = 0.00, Environment (Green) Cost = 200

Transp. Var. Cost per unit (per 1000 Kms) (in $) = 45.00, Environment Cost 20% of total cost

Sea

Transportation Time (per 1000 Kms) (in days) = 4

Transportation Capacity (No. of units) = 10000

Transportation Fixed Cost (per 1000 Kms) (in $) = 10000.00

Transp. Var. Cost per unit (per 1000 Kms) (in $) = 20.00, Environment Cost 15% of total cost

Discussion on Simulation Results

The data from the simulation run is stored and then analysed to obtain tables 1,2,3,4 and 5. Table 1 shows the effect of transport time over cost incurred per item. This shows the significance of increment in transport time and corresponding effects on various supply chain members. Table 1 shows the result for simulation run when we consider only road transport for all the supply chain members. The manufacturer's role in supply chain is most important. Distance, Lead-time, and demand size are some factors, which contribute a lot to affect the manufacturer's performance. Due to distance, lead-time and the demand size factor, manufacturers have higher cost (i.e. 83.75 to 104.60 and overall cost 101.5 to 210.5) that increases gradually by increasing transportation time. The environment effect (10 to 21.08) increases with the increase in the transport time. We analyse this for incremental time values due to inherent uncertainty of time. Road transport normally consumes notable fuel and is less energy efficient.

Table 2 shows the effect of transport time over cost incurred per item for rail distribution case. Rail has a larger capacity and takes almost half the time compared to road transport. It is also advantageous over the air transport because of its load carrying capacity and fuel consumption per unit dispatched. Most of the organizations use this transport mode more frequently but this mode also has some limitations such as it cannot transport the product up to the factory site. Rail is also a preferable transport because of more environment friendly features (e.g. electricity used as a fuel). However, relative to road transport, Rail has a much higher cost and is suitable only for the supply of massive quantity. It is not suitable for small quantities. We consider some of these factors in our simulation model. The value of environmental factor varies from 2.16 to 2.69, which is significantly small. Rail (e.g. electricity-based) is highly energy efficient. Although road transport incorporates far less cost compared to rail, because of its environment friendly features, Rail gives better results than road transport. Rail transport is also least affected by incremental transport time.

Table 1: Cost incurred per item delivered in the Road Distribution Method

TT	R1	W1	D1	M1	T	EC
100.00%	3.27	11.41	22.71	83.75	101.05	10.10
111.11%	3.27	11.41	22.71	83.75	101.05	10.10
122.22%	4.56	13.52	25.09	88.75	109.95	10.99
133.33%	6.01	15.69	29.25	88.75	116.77	11.67
144.44%	7.99	17.88	31.91	93.75	126.47	12.64
155.56%	7.99	17.88	31.91	93.75	126.47	12.64
166.67%	10.07	20.57	35.42	98.75	136.98	13.69
177.78%	14.98	24.63	36.57	100.39	164.23	16.42
188.89%	21.83	34.29	38.60	104.60	210.80	21.08
200.00%	21.83	34.29	38.60	104.60	210.80	21.08

TT: Transport Time R1: Retailer 1
W1: Wholesaler D1: Distributor 1
M1: Manufacturer 1
T : Total (no environmental cost)

Table 2: Cost incurred per item delivered in the Rail Distribution Method

TT	R1	W1	D1	M1	T	EC
100.00%	4.68	11.37	23.72	81.76	108.19	2.16
111.11%	4.68	11.37	23.72	81.76	108.19	2.16
122.22%	5.67	12.12	25.66	87.13	114.10	2.28
133.33%	2.55	12.97	27.82	91.47	117.14	2.34
144.44%	2.55	12.97	27.82	91.47	117.14	2.34
155.56%	2.66	14.29	32.06	102.25	127.03	2.54
166.67%	2.66	14.29	32.06	107.25	127.03	2.54
177.78%	3.32	16.10	34.46	107.25	134.88	2.69
188.89%	3.32	16.10	34.46	107.25	134.88	2.69
200.00%	3.32	16.10	34.46	107.25	134.88	2.69

TT: Transport Time R1: Retailer 1
W1: Wholesaler D1: Distributor 1
M1: Manufacturer 1
T : Total (no environmental cost)

Table 3 shows the effect of transportation time over cost incurred per item for air distribution case. Air is the fastest transport mode available but also has a limited applicability. It is more useful in geographically dispersed supply chain where rail and road transport is difficult, costly and time-consuming. We associate the air cost as per the supply chain requirement (i.e. distances) but it may vary with the global requirements. The air-based transport mode is mostly suitable where the supply is urgently required or time is more important than cost. The critical environmental cost is quite high in this mode (24.52 to 25.80). Air mode is not an environmentally suitable one due to high fuel consumption that

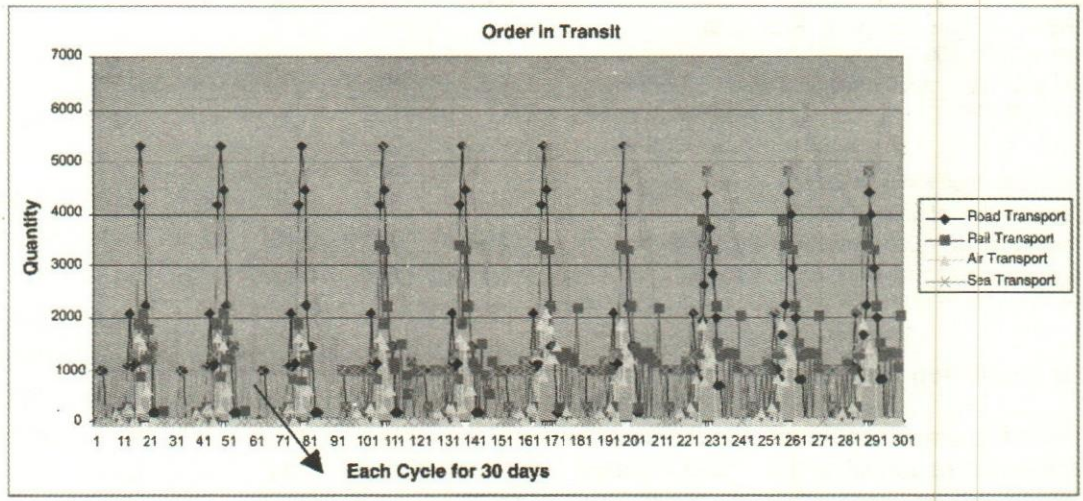


Fig. 7. Orders in Transit for Incremental Transport Time (For Road, Rail, Air, and Sea Transport)

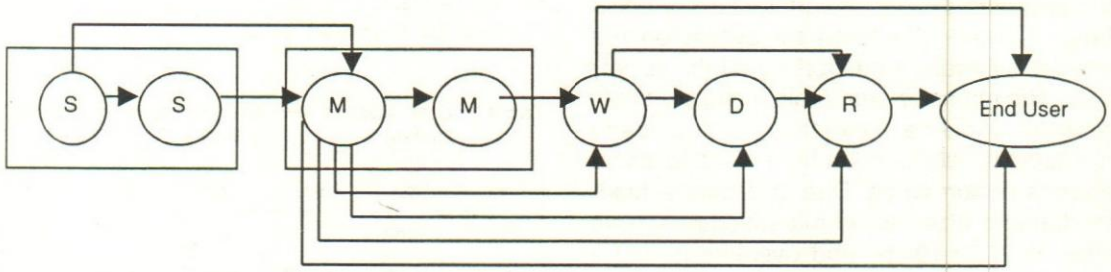


Fig. 8. Nodes based Flexibility (Routing) to Reduced Total Transit Time

affects the environment. However, on the other side it takes almost negligible time as compared to other modes and is the best mode to transport goods when boundaries are geographically dispersed.

Table 3: Cost incurred per item delivered in the Air Distribution Method

TT	R1	W1	D1	M1	T	EC
100.00%	6.18	13.34	28.66	90.31	122.61	24.52
111.11%	6.18	13.34	28.66	90.31	122.61	24.52
133.33%	6.18	13.34	28.66	90.31	122.61	24.52
144.44%	6.18	13.34	28.66	90.31	122.61	24.52
155.56%	4.70	13.37	28.72	91.76	123.36	24.67
166.67%	5.69	14.12	30.66	97.13	129.02	25.80
177.78%	5.69	14.12	30.66	97.13	129.02	25.80
188.89%	5.69	14.12	30.66	97.13	129.02	25.80
200.00%	5.69	14.12	30.66	97.13	129.02	25.80

TT: Transport Time R1: Retailer 1
W1: Wholesaler D1: Distributor 1
M1: Manufacturer 1
T : Total (no environmental cost)

Table 4 shows the effect of transport time over cost incurred per item for sea distribution case. Sea has a higher environmental cost (18.99 to 36.98) that varies

Table 4: Cost incurred per item delivered in the Sea Distribution Method

TT	R1	W1	D1	M1	T	EC
100.00%	3.32	15.36	31.96	100.59	126.62	18.99
111.11%	3.32	15.36	31.96	100.59	126.62	18.99
122.22%	4.60	17.57	34.31	105.59	135.42	20.31
133.33%	6.06	19.78	38.46	105.59	142.18	21.32
144.44%	8.03	21.97	40.88	110.59	151.49	22.72
155.56%	8.03	21.97	40.88	110.59	151.49	22.72
166.67%	10.11	24.55	44.90	115.59	162.07	24.31
177.78%	15.03	28.87	47.07	118.52	195.05	29.25
188.89%	21.88	38.58	48.41	123.44	246.55	36.98
200.00%	21.88	38.58	48.41	123.44	246.55	36.98

TT: Transport Time R1: Retailer 1
W1: Wholesaler D1: Distributor 1
M1: Manufacturer 1
T : Total (no environmental cost)

drastically with increment in time. Sea normally is used to transport goods, which are not suitable to transport by air.

Table 5 shows the effect of transport time over cost

incurred per item for least cost distribution case that reflects the importance of least cost transportation in the industry. The transit time in least cost transportation mode varied from 1.07 to 2.61. To see the impact of environmental attribute we check the performance of the each transport mode in incremental transit time manner. The cost varied from 101.5 to 210.8, which is also significant toward reducing environmental impact as compared to the other transport mode. This shows that there is effective operation with optimum reduction of environmental impacts. Least cost transport simulation mode chooses the appropriate distribution / transport mode based on least system cost and time. This mode has the flexibility to choose any transport mode as per the situation. We found that the least cost transportation mode reduces environmental impact drastically. By choosing default values, it chooses Rail as a favourable transport mode. Without environmental considerations, this mode selects the most appropriate least cost transport mode but that would be less effective and less environment efficient.

Table 5: Cost incurred per item delivered in the Least Cost Distribution Method

TT	R1	W1	D1	M1	T	EC
111.11%	3.27	11.41	22.70	83.75	105.05	2.16
122.22%	4.56	13.52	25.08	88.75	109.94	2.16
133.33%	6.00	15.66	29.21	88.75	116.46	2.28
144.44%	7.99	17.89	31.89	93.75	126.46	2.34
155.56%	7.99	17.88	31.89	93.75	126.46	2.34
166.67%	10.07	20.58	35.40	98.75	136.96	2.54
177.78%	14.98	24.65	36.53	100.39	164.21	2.54
188.89%	21.83	34.30	38.56	104.60	210.78	2.69
200.00%	21.83	34.30	38.56	104.60	210.78	2.69

TT: Transport Time R1: Retailer 1
W1: Wholesaler D1: Distributor 1
M1: Manufacturer 1
T : Total (no environmental cost)

It is practically important to choose varied transport mode but in our case, we also consider the environment factor with governance support that also restricts the time and cost parameter up to some level.

Figure 7 shows the orders in transit for the entire transportation mode. The analysis of simulation depicts that orders in transit highly influence the total cost and total time that indirectly cause the environmental effects. Air mode takes a minimum transit time variation and sea mode consumes maximum transit time. This also shows the effect of incremental transportation time for different transportation modes. The energy efficient operation reduces environmental impact drastically by reduction of the number of cycle and total time. The environmental impact of product transport is primarily from energy consumed and air pollutant emissions. A consideration of this impact is important in a GSCM.

When deciding how to ship products, one has to consider many factors such as cost, volume, reliability, delivery time, distance to customer, environmental impact. Efficient routing of transportation and distribution can significantly reduce the environmental impacts of a supply chain logistics system. We can also reduce the environmental effect by choosing right routing decision in the supply chain. Simply choosing the alternative routes in a supply chain can reduce the distribution time and cost. Routing in GSCM may warrant further investigation and discussion in future research.

There is one other strategy to reduce environmental impacts by reducing lateness and improving earliness in supply chain. This can effect the overall supply chain inventory, waste and distribution cycle. Table 6 shows the detailed output generated through simulation to support our approach. We consider five different performance criteria that ultimately affect the environmental impact. The results are showing that the Rail (fill rate 80, earliness 1.83 and order cycle time 1.17) performs the best when we choose the least environment cost method. Rail is more environment friendly and energy efficient because it uses electricity as a fuel. Also it is a fast and reliable transport mode. In addition, we cannot stick to one mode; we have to choose our mode of transport according to distance, cost time and area-based requirement.

Table 6: Shows The Impact Of Other Performance Factors Critical To Environment (Green SCM)

	Fill rate	Avg. lateness	Average Earliness	Order cycle time	Avg. Inventory level
Road Trans.	63.16	1.18	1.33	2.75	3474.23
Rail Trans.	80.00	0.30	1.96	1.17	3193.17
Air Trans.	92.86	0.09	2.16	0.76	3927.40
Sea Trans.	83.16	0.98	2.03	2.45	3774.23
LC	176.16	0.68	1.83	2.35	2575.13
LC 2(environ.)	80.00	0.30	1.96	1.17	3193.17

The following recommendations will take a SCM towards GSCM: (a) motivate to work with local supplier to avoid longer product transport distances, (b) motivate to introduce efficient forms of distribution, e.g. the simultaneous distribution of larger amounts of different goods, (c) use standardized transport and bulk

packaging, (d) Use route optimization (e.g. simulation oriented) to reduce product transport distances.

Government's product-oriented environmental policies are growing rapidly and can contribute significantly in this area. Government facilitates the industry to provide environmental information on products and processes, requiring business to pursue more proactive environmental policies. KM based e-governance supports the SC to various activities, which are directly related to green performance. The knowledge gain from government and industry processes can be easily adopted as an input for simulation. Simulation can further explore the knowledge by evaluating alternative options. E-governance system also encourages companies to carry out research into potential environmental improvements. This can also support transportation and distribution methods, energy-intensive production methods and energy/raw material consumption. Hence, it is necessary to add KM based e-governance to the GSCM.

Implications of KM-based GSCM Simulator on e-Governance

To consider the environmental impact of a supply chain consisting of many autonomous SMEs, a KM-based GSCM simulator can be very useful. The outcomes of the GSCM simulation models can help in regulating the environmental impact of a supply chain. The knowledge generated from GSCM simulation models can be shared in G2B and B2G interactions' environment for better performance of businesses. The knowledge can also help in effective sharing amongst SMEs facilitated by KM-based e-governance. Given a supply chain, the optimum operating conditions considering both the cost and environmental impact, as shown by our GSCM simulation model, might be different from optimum cost operating conditions. Reduction in environmental impact is also possible from another avenue, by controlling the demand pattern. It might be possible that for a slightly different demand pattern the environmental cost may reduce significantly. This would need re-engineering of consumer characteristics and consumption pattern, which can be achieved by increasing the GP awareness of the consumers. By knowledge sharing the SME chain members may also share actual demand so as to avoid undue amplification and distortion of actual demand. Consumers need to know that it is not the responsibility of manufacturers only to save the environment; their consumption practices can also play an important part. The KM-based e-governance can use and share the demand knowledge effectively to motivate existing consumer practices into more desirable directions. GSCM simulation models can play an important role here by helping to determine the demand patterns, which produce more environment friendly results without affecting the business performance. Moreover, the investments made in such e–governance will be recovered to a significant extent by the saved environmental cost. The SMEs stand to benefit most from such KM-based GSCM simulators operating in e-governance environments.

Conclusion

This paper has presented an integrated transportation based demo model to incorporate environmental impact to GSCM. E-governance plays a role of facilitator and controller for GSCM operations. KM-based e-Governance can help effectively in this direction. KM-based e-governance system provides the easy way to acquire desired knowledge, which can be supportive in decision making. The simulation study results motivate us to give more attention towards distribution system. It has exhibited its potential advantages in addressing complicated GSCM problems corresponding to governmental regulations for environmental protection, e.g. the control over environment regulation, better IT application, research and development and more appropriate environment-based industry-government interaction. Hence the use of KM-based e-governance can lead to better decisions, especially by SMEs to improve the services to the larger businesses. The SMEs can be proactively supported by KM-based e-governance on various environment-related knowledge so that they can be effective partners of a Green Supply Chain. The KM-based GSCM simulator can play an effective role to increase the SME awareness about logistics strategies that can improve the chain performance while giving adequate importance to the environment.

References

APO (1999), "Green Productivity Practices", Environment Department, Asian Productivity Organization, Tokyo.

Beamon B. M. and Fernandes C. (2004), "Supply-chain network con?guration for product recovery", Production Planning & Control, Vol. 15, No. 3, 270–281.

Beamon, B. M., (1998), "Supply Chain Design and Analysis: Models and Methods", International Journal of Production Economics, Vol. 55, No. 3, pp. 281-294.

Gilbert, S. (2001), "Greening Supply Chain: Enhancing Competitiveness through Green Productivity" pp 1-6. Tapei, Taiwan.

Graedel T. and Allenby B., (1995), "Industrial Ecology". Englewood Cliffs, NJ: Prentice-Hall.

Gupta M.P., Kumar P., Bhattacharya J., (2003), "Government on line: opportunities and Challenges". Tata McGraw-Hill.

Handeld RB, Nichols EL. (1999), "Introduction to supply chain management". New Brunswick (NJ): Prentice-Hall.

Heyman, D.P., (1997), "Optimal disposal policies for a single-item inventory system with returns". Naval Research Logistics Quarterly 24, 385–405.

Humphrey, J. Schmitz, H. (2001), "Governance in Global Value Chains". ISD Bulletin, vol 32.

HWA, T. J. (2001), "Green Productivity and Supply Chain Management. Greening Supply Chain: Enhancing Competitiveness Through Green Productivity" pp 23- 28. Tapei, Taiwan.

Khoo, H. H. et al. (2001), "Creating a Green Supply Chain". Greenleaf Publishing pp 71- 87.

Lamming, R. and Hampson, J. (1996), "The Environment as a Supply Chain Issue", British Journal of Management, Vol. 7, pp. 45-62.

Nonaka, H. Takeuchi, (1995), "The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation", Oxford Univ. Press, New York.

Okot-Uma R., (2001), "Electronic Governance: Re-inventing Good Governance", Commonwealth Secretariat London.

Richter, K., (1996), "The extended EOQ repair and waste disposal model". International Journal of Production Economics 45 (1–3), 443–448.

Sarkis J., (2003), "A strategic decision framework for green supply chain management". Journal of Cleaner Production 11, 397–409.

Simpson, V.P., (1978), "Optimal solution structure for a repairable inventory problem". Operations Research 26 (2), 270– 281.

Stock, J.R. (Ed.), (1998), "Development and Implementation of Reverse Logistics Programs". Council of Logistics Management, Oak Brook, IL.

The MIT Beer Game, Aug 20, 2003. http://beergame.mit.edu/

Tiwana A., (2000), "The knowledge Management toolkit", Prentice hall.

Wadhwa, S., (2001), "Judicious Use of IT in Manufacturing SMEs: Case Experiences", International Symposium on IT for Small Industries, APO Publications.

Wadhwa, S., Rao, K.S (2004), "A Unified Framework for Manufacturing and Supply Chain Flexibility", Global Journal of Flexible Systems Management, Vol. 5, no.1, pg 15-22.

□

Money is of no value; it cannot spend itself. All depends on the skill of the spender.

– Ralph Waldo Emerson

Higher Education in India – Alternatives through e-education

Ram Takwale

This paper deals with the Indian educational system with the approach of facing challenges of globalisation through e-education, and discusses possibilities of using existing IT developments in the field of higher education so as to enable it to address many problems. The creation of a national knowledge network to support weaker institutions, and to offer opportunities to evolve new paradigms of developmental education, has been suggested.

Ram Takwake is an Emeritus Professor in the University of Pune and Yashwantrao Chavan Maharashtra Open University, Nasik.

With all the impressive development in the areas of Information Technology, space science, nuclear technology, oil exploration, industrial production etc., India has been unable to solve its problems of poverty, ignorance and underdevelopment.

The major challenge for the country is to use IT and evolve a new system of education that may enable educational institutions to develop appropriate paradigms of development and education, and to increase coverage by serving larger numbers so as to move towards education for all.

The Education Scenario

India has one of the largest systems of tertiary education with more than 300 university-level institutions, 14,000 colleges, 9 million students and 0.4 million teachers.

The non-formal mode of distance education consisting of 10 national and state open universities, nearly 60 Distance Education Institutes of traditional universities, together account for nearly 20% enrolment.

The size of the total system appears to be quite large and impressive, but it covers hardly 6% of the relevant age-group. In order to compare well with the developed countries having coverage of about 30-40 %, India has an enormous task of creating a huge infrastructure, which will require financial resources not affordable to the nation. It is therefore necessary to evolve some alternative and new way of increasing coverage and for offering more access to a large number of aspiring learners, at a minimum cost.

The single and dual mode universities as well as conventional universities are now using Information Communication Technologies (ICT) for various purposes. This has created a new scenario of modes of education which can be classified as follows :

1. *Formal Education:* Classroom/campus-based education imparted by traditional universities.
2. *Non-formal Open and Distance Education:* Offered by single mode open universities.
3. *Mixed Mode Education:* Offered by Distance Education Institutions (DEI) of traditional universities by using both formal and non-formal components of the two modes.
4. *ICT Based Convergent Mode:* Uses Web Based Education (WBE), Computer Based Education, Centre/Classroom Based Education. Some universities are using ICT and Internet extensively in education to supplement the print based /classroom based mode in formal and/or non-formal education.
5. *Entirely WBE e-education:* Uses Internet and WBE extensively.

No mode described above is going to be in its pure form, and many educational institutions will be using ICT conveniently to serve their purposes in a variety of ways.

The contemporary educational system offers education on a mass scale, without providing any personalised attention. A radically different formulae is required when ICT is used, so as to relate it to support developments in living and working places of people who come from a variety of backgrounds.

IT-enabled Transformation of Education

The main features of learning and education are:–

- Learning is a personalised process and includes internalisation of knowledge by a learner.
- Teaching is a dialogue between a learner and teacher and is best when it is on a one-to-one basis.
- Learning can take place anywhere anytime; one should know how to learn. Learning to learn is a basis of education.
- Basic learning and teaching process should be independent of modes of education - formal, non-formal and informal.

Information Communication Technology could assist in ensuring personalisation of education and increasing intimacy in dialogue between teacher and student. e-education is used to denote both the shifts from the traditional and open and distance education to the e-content based educational system in a convergent mode – e-education in Convergent Mode or Convergent e-education, which will be relevant during the transitional period. It is assumed that this transition will be complete when broadband Internet connectivity and IT appliances are widely available.

Information Communication Technology could assist in ensuring personalisation of education and increasing intimacy in dialogue between teacher and student.

There are two mega paradigm shifts in education. The first is from traditional university to open and distance education (ODE), and the second is from ODE to e-education. Both the traditional and ODE universities are essentially based on industrial models of education – offering mass education. The new paradigm of e-education is, however, of a non-industrial form and should offer personalized education on a mass scale (mass personalisation).

The first transformation – the first paradigm shift - is from institution-centric localised education to education at the doorstep of a learner, offering a lot of flexibility in place and pace of learning and choice of courses. The open universities developed well-structured pedagogically-designed instructional materials, packaged them in the conventional form of courses and programmes, and delivered them through study centres/workshops with local instructor support; and gave certification after course-end examinations. The Indian open universities used the Study Centre approach to extend educational services and support to distant learners.

However, the packaging and delivery of the courses is the same as that of the traditional universities, and hence the process and model of education has, on the whole, remained the same.

ICT is offering an opportunity of redesigning and developing new models of education. While considering this shift it is essential to concentrate on the five main processes of any educational institution:

- Educating: Teaching, Learning, Evaluation,
- Creating Knowledge Resources,
- Developing Infrastructure Facilities,
- Creating Educational Environment and
- Managing Education

While using IT, the processes have to be designed and developed in such a way that education can successfully address the problems of quality, quantity, equity, access and even the success of large numbers of students.

e-education

e-education is essentially the same education with the same basic processes of educating, creating, developing and managing, which are carried out by individuals, institutions and communities for achieving the goals of education. In the information age it is supported by IT-enabled and IT-driven processes made accessible through IT tools and techniques to make education globalised, localised and personalised. The outcome of this application of technologies would be in a form of organisations and institutions, which may be quite distinct and different from the existing institutions.

Networked society will require an educational system that will be able to offer educational opportunities to all anywhere, anytime.

Any networked society will need:

- *Network* with broadband connectivity linking hardware and appliances at various places for giving access to anyone, anytime, anywhere.
- *Software tools*, techniques and applications for enabling people and groups to communicate with others quite intimately.
- *Content* needed and shared by groups of people, organisations/institutions, which enables providers to offer services to users and customers.

An example of a network is that of railway and air travel network, in which content is the information of places, schedules, services etc. that enable one to make a reservation from home for travel from any one place to another. With greater ICT use, the trend is to offer services that would fulfill customer requirements (personalisation of services) and ensure customer satisfaction.

Education can now use the networking technologies for developing educational system (e-education). e-education system requires the following framework and infrastructure:

1. *Network* with latest hardware and technologies along with broadband connectivity and grid architecture giving network access to anyone, anywhere, anytime.
2. *Software tools and techniques* that enable creation of databases and information flows, offer facilities to learners, teachers and institutions to receive / give personalised education on a mass scale.
3. *Content in e-formats* on a knowledge grid that enables teachers and students to get personalised curriculum of high quality, relevance and utility.
4. *Educational delivery system* that ensures quality and developmental relevance of educational offerings (Developmental Education) for individual, institutions and community.
5. *Quality Assurance and Certification Mechanism* to maintain competitively high and acceptable standards at national and international levels.

The framework given above can serve as a national and regional infrastructure to support educational processes of any provider institution, individual and organisation in India.

Content development and delivery

By using all the media of print, audio, video, animation and simulation, content in e-education can be developed in the formats of:

- E-lectures
- Multi-media materials in distance education formats.
- Interactivity based content out of:–
  - * Questions and Answers, Seminars, workshops
  - * Assignments and projects done by students

Content output could be stored on servers at various places in the network.

In formal and non-formal systems, content packaging is done through a course of a programme, and delivered to a class of students or a group in a college / university. It uses the principle 'one size fits all' and does not take into account personal background, needs and requirements, prior learning and experiences as well as outputs and outcomes essential for a learner to be successful in a life and work situations. It is, therefore, essential to store content in such units that it can allow packaging of various units to suit the learner needs. Such methods and technologies are getting developed in e-education.

Content Storage-Meta-database

In e-education, content has to be developed and stored in such a way that a teacher or learner should be able to combine various small units or granules of contents (reusable content) with definite learning objectives and outcomes. A granule could be conceived as the smallest learning or teaching unit with single definite objective and output /outcome. A granule may contain a large number of content items, often called objects, in the form of texts, pictures, graphs, audio, video, animations and simulation, each one requiring study time of one to fifteen minutes. Each object could be tagged to reuse in different contexts and at different levels of learning.

A database could be created in which a large number of learning objects and granules are created and deposited by all the teachers and experts (universal content contributions) with tags attached to each object and granule. The tags will enable a search engine to select appropriate objects and granules to form a syllabus/curriculum needed by a student. This leads to a personalized syllabus for a student.

Database of such a transformed content will be extremely big -meta-databases- and could be made available and accessible to all learners and teachers. International norms are getting evolved in developing databases (SCORM compliance) so that databases could have wider accessibility, transferability and usability.

Content Delivery

Technologies are essential for offering personalised curriculum to each individual. They are being developed for various customisations. Such Personalisation Technologies allow teachers and providers of education to dynamically recognize the role and profile of each learner and respond according to the needs and requirements of a student. A good teacher will formulate a curriculum for the student (personalised curriculum) by prescribing learning (Prescriptive Learning) by identifying learning and knowledge gaps; and setting a correct learning path for the student. This will enable student to build on whatever is known and achieved earlier and reach the objects/goals set for him/her in the curriculum. Such a learner-centric approach achieved through educational technologies will ensure success for every student. The e-education framework and infrastructure through personalisation technologies will ensure 'access and success' in the field of education.

IT Enabled and IT Driven Education

Many formal and open universities are at present using IT for fast communication between institution/teachers and students, and for administration of student and teacher activities. These are the 'first generation' technologies and help the provider institution to achieve better efficiency, reduce costs and extend outreach and coverage to a larger number of students outside the usual jurisdiction of an institution. This may be called IT-enabled education (enabled by 1st Generation Technologies), since it basically does not change the model of education, and retains the earlier methods and processes of teaching-learning and evaluation.

Development of Meta-Database with reusable content granules and packaging of the content to suit individual needs is creating personalisation of education enabled only by the use of technologies. The learning technologies developed and used for learner-centricity and personalised education are termed 'second generation' technologies and offer IT Driven Education. They are changing the methods of content generation, content storage, content packaging and content delivery and hence offer a new paradigm of education.

With appropriate models of development and delivery it is possible to employ IT-driven education to achieve:

- Access and success to all
- Substantial cost reduction
- Quality education for all
- Just-in-time education
- Learner autonomy

The learner autonomy would employ learner freedom in deciding the goals, content and outcome of education and the path of development to achieve the goals.

Many of the problems and concerns could be addressed successfully by creating National and Regional e-education Network with a framework and infrastructure.

Existing Trends in Networking and Infrastructure Developments

Many national bodies and organisations have taken an initiative to create infrastructure and facilities to support education in various ways. Some of the initiatives are listed below:

- UGC has taken the initiative to create a network,

which could connect all universities and most colleges in India by creating a network and by offering resources for developing IT infrastructure in universities and colleges. The UGC has also undertaken a programme of e-content creation and development of guidelines and programme, which will enable students to take courses or degree/diploma from more than one university. Universities, jointly in partnership, can offer courses and certification.

- Indian Space Research Organization (ISRO) is developing an EduSat with more than 50 channels with ku-band transmission. ISRO has already started pilot projects to create distributed classroom, e-content and educational applications in three states: MP, Maharashtra and Karnataka. The pilot programme in YCMOU at Nasik aims at creating a network of distributed classrooms with teaching at Nasik and receiving rooms at about 100 places in Maharashtra.
- IGNOU has a national TV channel for education, and is going to have about 5 more channels to support higher and school education as well as agriculture education.
- Maharashtra Knowledge Corporation (MKCL www.mkcl.org, www.parivartan.net) in Maharashtra has established a network of about 3500 network access centres, which covers 330 blocks out of the total of 360 in the state. Network uses e-governance, works entirely on paperless environment and has enrolled half million students within 15 months period. MKCL is also developing software for digital college and digital university, learning/content/delivery management systems and is engaged in developing e-assessment and accreditation system in partnership with NAAC.

All these efforts could be integrated and a national network could be built by providing a direction for development and support for infrastructure.

New Age, New Education

Development and extensive use of network would enable to incorporate enabling functionality and related values in the programmes of learning social groups and organisations using the Framework. Networking enables convergences of services offered by various providers. One obvious impact will be the convergence of modes of education. Formal and non-formal institutions – traditional universities and open universities-will be using distributed classrooms and distance education technologies for reaching out to a distant learners.

Networking and extensive use of IT enables:

- Integration and Convergence
- Globalisation
- Decentralisation and localisation.
- Personalisation
- Transparency and openness.
- Omnipresence of information and knowledge.

If these principles could be incorporated in the design and development of IT enabled and IT driven processes of social mobilisation and organisations, the nature and character of the emerging society could be different.

Such a system can promote a culture of participatory democratic decentralisation, accountability and local relevance and help in efforts for total development of a locality and local community.

Paradigm shift in education is essential

Learning – Teaching - Evaluation		
From Teaching	To	Distributed and group Teaching
From Classroom	To	Distributed Classroom
From Learning from a teacher	To	Learning from Resources, group of teachers /experts and through Interactivities.
From Content Learning	To	Objectives and Outcome-Oriented Learning
From Course Content	To	Granulated Object-Based Content forming - Meta Database
From Examinations	To	Continuous Formative and Summative Evaluation.
Educational Management		
From Education	To	Development Education.
From Whole Time education	To	Just-In-Time Education
From Campus education	To	Distributed Education
From Campus Environment	To	Virtual Educational Environment
From a Single Institution	To	Consortia of Institutions / Distributed Institutions / Virtual Organisations
From Mass education	To	Personalised Mass Education

Distinction between formal, non-formal and informal education will disappear once transition to IT-driven education is complete. The process may take a decade or two.

New Age New Organisations—Virtual Universities

Over the last few years, many universities and colleges are getting ready to face the impact of

globalisation and emerging competition in marketing education by forming a consortia of colleges and universities. The major approach employed is to partner with other colleges and universities and to offer the best available educational expertise, courses and services to students both on-campus and off-campus. This is also aimed at the survival of small institutions against the competition from the big ones. Many colleges and universities have formed partnerships – virtual universities – by using essentially 'first generation technologies' for becoming competitive and earning resources to support their institutional development.

The Concept of a Virtual University

The concept of a virtual university is of a consortium of institutions, enabled by appropriate ICT applications, working together in practical ways to plan programmes, develop the required content and ensure the delivery of those programmes and support services to learners.

The concept of a virtual university is of a consortium of institutions, enabled by appropriate ICT applications, working together in practical ways to plan programmes, develop the required content and ensure the delivery of those programmes and support services to learners.

Three features of the university need to be underscored:–

- The virtual university is not being proposed as a university in the conventional single institutional sense. It will, in fact, be a "virtual organisation"
- The virtual university will carry out its functions by optimising ICT applications, particularly those that enable the creation and deployment of content databases based on learning objects and granules
- The virtual university will be as much concerned with "adding value" to conventional on-campus instruction as it is with serving learners at a distance.

It is therefore a bold and challenging vision of a virtual university that has the promise of enabling the consortium of member institutions to become leaders in development of education models that can be tailored to the realities of the learners they serve.

The virtual university is a concept at the initial stage of development and operations, and offers an opportunity to radically transform the existing models and practices of education. Education can now be made central to all the human developmental activities by developing radically different paradigms of education.

New organisations appropriate for the 21st century are getting developed. The Virtual University for Semi-Arid Tropics (VUSAT) by ICRISAT, Hyderabad and MS Swaminathan Foundation, Chennai, Virtual University for Maharashtra Agrarian Prosperity (VUMAP) by Agriculture Department, Government of Maharashtra, Virtual University for Trade in Kerala and MS Swaminathan Foundation's Virtual University for Food Security are some initiatives at their initial stages of development. Virtual universities use broadband connectivity and second generation technologies.

Evolving National e-educational Network

By employing IT expertise and experiences of the IT industry and IT educational institutions, it is possible to design the National e-Educational Network prescribed earlier that would support all universities, colleges, teachers and learners in their pursuit of knowledge and development.

Development of such a network would create an infrastructure and framework, which could help weaker and disadvantaged colleges and universities to join regional/national consortia and offer best educational services to their local students by offering personalised services.

The major components of the National Network will be:–

1. *National educational network connecting* all institutions and their classrooms through broadband connectivity.
2. *Indian Knowledge Grid* to enable content to flow to anyone anywhere and anytime.
3. *Granulated Object-Based Content* in a Meta-database
4. *Promotion of national and regional* level consortia of colleges and universities
5. *National quality assurance and accreditation mechanism.*
6. *National and regional credit banking and certification* mechanism for students to take education from different universities/colleges.

7. *Movement for giving services to weaker and disadvantaged for ensuring quality, justice and quality for all.*
8. *Promotion of public-private partnership* for creating self-employment for graduates in various fields of human activities.

Such a National e-Education Network could help in addressing the problems and concerns listed at the beginning.

Concluding Remarks

Since independence India has been struggling to evolve its Indian National System of Education, and ensure that it is capable of addressing the issues of quantity, quality and access and success on the basis of Indian culture, heritage and value system. The National/ Regional e-Education Networks will enable the Indian educationists to evolve new models of education that can shape emerging new society; and new strategies in 'marketing' of education with developmental models appropriate to the developing society.

National and social objectives of e-education in a developing society have to fulfill aspirations of the people and nation and address the age-old problems of poverty, ignorance, underdevelopment and disadvantages. If the education system is given the right framework and national infrastructure, it can come up to the centre stage in every activity of human endeavour and give academic leadership in a knowledge-based society. The crucial test lies in addressing age-old problems successfully by mobilizing common people and creating learning communities to achieve *Antyodaya* (upliftment of the lowest) with equity and justice. This opportunity to build a New Indian Education System and new society comes only once in a millennium.

(The full text of this paper can be downloaded from www.ugc.ac.in). □

Under budgetary pressure (arbitrary or not) it is truly remarkable how many options one discover one can do without.

– James R. Schlesinger

Feature

Spectrum Investment Economics of Mobile Wireless Industry

Hemant K. Sabat

By analysing wireless spectrum distribution mechanisms and spectrum regulatory instruments in various countries, this paper describes how national and international regulatory bodies along with national governments play an important role in shaping spectrum dynamics of the mobile wireless industry. It also describes the spectrum acquisition strategies in the context of how the industry's spectrum investment economics is leading to the emergence of a stable mobile wireless industry.

Hemant K. Sabat is General Manager of the Telecom & High-Tech division at Perot Systems Corporation.

A series of radical technological leaps in mobile wireless devices, networks, business models, and applications is setting the stage today for mobile wireless communications to transform from mobile voice to the ultimate communication media. To capitalise on the opportunity, the industry stakeholders have to assess the impact of a mobile wireless network operator's capital investments on the industry, which is best understood by looking at the value propositions, the value chain, the components of capital investments, and its impact on operator's cash flows. The mobile wireless value propositions and the value chain are described in earlier papers (Sabat, 2002a & b). The business economics of the mobile wireless industry is described in another paper (Sabat, 2005a).

The mobile wireless subscribers want a convenient, secure, reliable and personalized serviceøall at a value-based price. The value chain has been evolving to enable these value propositions. Analyzing and organizing the established and emerging players in the industry based on their offerings leads us to the current evolutionary state of the value chain and its elements (Sabat, 2002a; Sabat, 2002b). To effectively manage this chain, the mobile wireless industry has evolved through three chronological phases: the birth through the land-grab to the emerging mobile wireless (Sabat, 2002c). Leading the evolution of the value chain through these phases and driving the dynamic landscape are the telecom regulations and fundamental industry drivers, at the macro-level, and business drivers, at the micro-level. Restated, capital investment and business economics have governed the viability of the industry. The industry's key economic characteristics are a result of these drivers. Of the key economic indicators, critical to the industry's success are the network operators' top line business drivers such as pricing pressures, the network operators' capital and operating cost drivers, the competitive landscape, and the service providers' offerings (applications and services). Of the cost drivers, the most influential on the industry's dynamics is the capital

investment (or capital expenditure, or capex) (Sabat, 2002c). As difficult market conditions persist, it is crucial to look at the impact of heavy investments on funding and liquidity positions, and develop ways to reduce uncertainty that will lead to the emergence of a stable value chain. To do this requires an in-depth understanding of the capital investment economics of the mobile wireless industry.

A network operator's cost equation consists of capital and operational expenditure (or recurring costs). The recurring costs include interconnect fees, site rental, maintenance and power. Based on a study conducted by the author that included analysis of capital investment patterns over the last ten years of more than 300 wireless network operators operating across the world, it is inferred that the industry's capital investments are driven by the following factors:-

- *Coverage* requirements of the operator (national, regional, hot spot areas only) There are added variables here such as handset availability in a multimode environment as well as roaming capabilities from 2G through 2.5G to 3G (Sabat, 2002a).
- *Capacity* (expected number of users in the hotspot areas)
- *Service* features that operators plan to offer to subscribers
- *Bandwidth* requirements to offer wireless content to subscribers

Accordingly, a network operator's investments fall into two categories: spectrum license fees paid to the government of the land by the spectrum owner to acquire radio spectrum frequency rights and offer wireless services in a given geographical area, and telecommunications infrastructure spending by the network operator to build a network in the licensed markets.

Though the investment to acquire spectrum is a one-time investment, its size as a proportion of the mobile network operator's total capex makes the business world tremble. In India, Bharti Cellular, a mobile operator, spent Rs. 6.9 billions to capture eight of the 17 licenses auctioned in July 2001 (Menon, 2001). From an understanding of the fundamental nature of airwaves, we know that the total spectrum bandwidth available for wireless use is fixed. All of the wireless service providers operating in a given region or market share this fixed spectrum resource. Therefore, network operators' access to spectrum in the market is limited. However, a carrier can offer wireless services only if it owns the license to use a particular spectrum band in the region. From this follows two conclusions. One, since radio frequency band segments in a region are limited but are required to offer wireless services, they are *scarce*. Two, since spectrum is the lifeblood of the wireless carriers, without it, they have no service offering. When they run out of spectrum, they can no longer add more subscribers or deploy new services. Therefore, spectrum is a *commodity* too. Also, by its very nature, radio airwaves are a *public* resource, and hence, radio spectrum must be regulated by the government on behalf of the society. In the final analysis then spectrum is a *scarce public commodity* to be utilised for the greater good.

True to its scarce commodity characteristics, there is a shocking premium on spectrum's real value. Therefore, the influence that spectrum has on a network operator's capex, and hence, its cash flow from operations, cannot be overstated. In light of this influence, which ultimately decides sustainability of a network operator's business and of the industry at large, an understanding of how spectrum is distributed, and how spectrum market is regulated is essential.

While spectrum availability has been one of the key factors driving the industry's growth, spectrum trading is still in its infancy, as the industry is still very young. This is why whereas the industry's newsbytes offer snippets on spectrum distribution mechanisms and rulings and developments as they occur, the evolution of radio spectrum investment economics has outpaced the research in the field. By providing an integrative view of the spectrum rulings of wireless regulatory bodies in the U.S., Canada, many countries in Asia, South America and Europe, this paper discusses how national and international regulatory bodies along with national governments play an important role in shaping the spectrum ownership dynamics of the industry. This paper also describes the impact of these rulings on the market structure, and on the spectrum acquisition strategies pursued by the mobile network operators to sustain a profitable business. By analysing recently-held wireless spectrum auctions in various parts of the world, and spectrum acquisitions strategies followed by operators in the last decade, this paper describes network operator's spectrum acquisition strategies and their key drivers.

While spectrum availability has been one of the key factors driving the industry's growth, spectrum trading is still in its infancy, as the industry is still very young.

The role of national governments, and regulatory bodies in spectrum industry

As the guardian of spectrum – a public resource – the national government of each country awards operators the licenses to use the spectrum. To maintain uniformity in spectrum allocations across various countries (for reasons of safety, technology, roaming and others), international standard-setting bodies suggest the governments various spectrum bands for specific use. For example, international standard-setting bodies, namely the International Telecommunications Union (ITU) and World Radio Congress (WRC), have suggested various bands for 3G use. The ITU originally nominated the bands 1885-2025 MHz and 2110-2200 MHz for 3G use. Within these bands, each national government was to select the amount of spectrum to be made available for 3G services, taking into account competing demands and uses of the spectrum. The ITU also allowed for any 1G and 2G spectrum to be used for advanced wireless services. The WRC, the international body responsible for radio spectrum allocation, identified additional spectrum bands for the provision of 3G (1710-1885 MHz, 2500-2690 MHz, and 806-960 MHz). The WRC stated that 160 MHz of additional spectrum could be needed to support 3G services by 2010.

Spectrum being a scarce public commodity carrying an exorbitant premium, billions of industry liquidity is at stake, and hence, it guides the mobile wireless industry's profitability. The 3G spectrum allocation in Europe is a case in point where network operators spent US$120 billion in 2000 to acquire 3G licenses from their respective governments (Carvalho *et al,* 2001a & b; Lundberg & Carvalho, 2001). Most recent spectrum auction results across the world provide a testimony (Sabat, 2003). Such an enormous impact on the nation's capital flows, and that of the world's at large, impels national governments to distribute spectrum and regulate its use.

Spectrum being a scarce public commodity carrying an exorbitant premium, billions of industry liquidity is at stake.

National governments regulate the distribution and utilization of spectrum through their regulatory bodies that are created to frame policies on their behalf. These regulatory bodies use multiple means to distribute spectrum to prospective buyers. Lottery, beauty contest and auction are the most-used methods.

In the U.S., prior to 1994, for example, the government awarded one of the two 25 MHz cellular licenses, which was available to a non-wireline operator, through a lottery system (Larsen *et al,* 2001). On the other hand, Ireland's regulator, Etain Doyle, awarded four licenses via a beauty contest in 2002 to Hutchison UK, Vodafone UK and mmO_2 (Richardson, 2001; BWCS, 2002a).

In a beauty contest, the licenses are awarded by evaluating the suitability of the bids against a set of criteria, as in Luxembourg (BWCS, 2002b). Further, the beauty contests may have an up-front fee accompanied by a deferred payment schedule, as in Ireland (Richardson, 2001). By contrast, in Canada, licenses at 1.9 GHz were awarded in 1995 by way of a beauty contest, with no up-front license fee required (Karleff, 2001). Whereas beauty contests assure national treasury a minimum payment for licenses, the spectrum prices in these markets run the risk of not being driven by market drivers. Therefore, network operators vote that the system is operationally inefficient, as in Ireland (Richardson, 2001).

By its very nature of being a chance-phenomenon, the lottery system undermines allocation of a public resource based on a logical, coherent approach to the economics of demand and supply. The result may easily be off from valuing the spectrum at its economic value, and the variation from the equilibrium market price will never be known in this method. As a result, both buyers and sellers fail to realise the economic value of the spectrum, a scarce public resource.

Due to their popularity as a spectrum distribution mechanism, a more incisive analysis of auctions is provided in an earlier paper (Sabat, 2003). The thesis is summarised below. Whereas in a beauty contest, the role of free market economics is undermined because the up-front fees are set by the regulator, auctions tend to be driven more by market forces. In fact, in the allocation of radio spectrum for mobile telecommunication services, the supporters of auctions point at essentially two benefits:

- By utilising in an efficient way the scarce commodity of mobile wireless industry, economic efficiency of the industry may be enhanced. This will benefit all the stakeholders of the industry. This is "economic efficiency" thesis.
- Auctions are also a cost-effective way to raise capital for the cash-starved national treasury. National governments can utilise these funds to initiate development in other fields. This is "raise-capital-for-cross-subsidy" thesis.

Whereas the potential of auctions as an instrument to regulate and distribute spectrum holds merit due to the two stated theses, its improper implementation could wreak havoc on the industry and economy at large due to its sheer enormous impact on the industry's liquidity and the economy's capital. Ensuring fair implementation of auctions faces practical impediments making it a Herculean task. Europe's 3G spectrum auction held in 2000 is a tell-tale example. The then much-hyped auctions tell a different story now. There is no doubt that these auctions *committed to raise* US$120 billions for the national governments (Carvalho *et al,* 2001a & b; Lundberg & Carvalho, 2001, p. 3). European operators paid a total of Euro 51 billion for 3G licenses in Germany, and Euro 12 billion in Italy. The U.K. auction raised UK£22.5 billion (US$33.75 billion or Euro 38 billion).

Although the early European auctions were regarded as successful in raising money for national treasuries in 2000, the amount of capital raised varied widely from country to country (Reuters, 2002a). Further, not all auctions held in Europe were as successful as the hype was. For example, Switzerland managed just Euro 125 million for four licenses. The recently-held 3G auctions in Israel raised 665 million Shekels (or US$156.8 million), which was below the one billion Shekels the ministry had hoped to raise in 2000 when European firms were paying vast sums for 3G licenses (Reuters, 2001e). What makes the scene worse is many national treasuries have yet to realise the full payments.

Further, a year later, the industry faced the reality specter of spectrum over-valuation wherein carriers found themselves deep in debt. Many debt-laden carriers have been returning some of their spectrum gains (Total Telecom, 2002; BWCS, 2002c). This partly explains the relative failure of subsequent auctions, but poor design and the failure to back them up with effective anti-collusion measures were also criticised in Italy, Germany and the U.K. (Source: Industry newsbytes).

To cap it all, after spending US$120 billion on 3G spectrum license fees, the debt-ridden Europe-based wireless operators are expected to spend at least another US$100 billion to build out their 3G networks (Mouawad, 2001; Mitchelson & Sarma, 2001). To add to their woes, mobile operators are feeling pressure from investors not only because of their debt burdens, but also from concerns that the new service will not turn out to be as profitable as first thought, largely due to reports that the transmission speeds will initially be lower than originally expected (Stevenson, 2001). This is because of the technological complications inherent in the formidable task of optimizing both voice and data, which exhibit different content characteristics, in the same transmitting medium at the same time.

As recourse from huge debts and these untenable market conditions, European governments are considering ways of letting telephone companies share investments for UMTS networks to cut their costs. However, these moves do not mean that there will automatically be similar relief for debt-burdened 3G operators in other major European markets, although there are some encouraging signs. The operators, on their own, are even considering ways to eliminate competing spectrum.

The auctions in the Asia-Pacific were held after European 3G auctions and had to face the cumulative wrath of the industry that was already negatively impacted by the poorly-designed auctions in Europe. This was further compounded by the design of auctions in Asia, which were, for the most part, picked from different parts of the world and planted without adapting to the local regulatory and cultural intricacies.

With such huge amounts of dollars at stake and such enormous implications, it is then imperative that national governments and their regulatory bodies continuously regulate the spectrum industry fairly and openly before and after distributing the spectrum. They strive to achieve this in multiple ways. Spectrum caps, a limit to the amount of spectrum one carrier could own in any given market, trading or transfer limitations, regulatory review, and ownership stake caps in domestic holdings are the primary restrictions placed on spectrum globally.

Spectrum cap is put in place when the market is young to ensure growth in competition. The cap arises out of the fact that spectrum is a scarce resource, and thus wireless market entry is limited. If adequate safeguards are not put in place, one operator could take over a large block of spectrum in a given market and thereby stifle competition. Stifled competition will promote the ills of an imperfect market-higher wireless subscription fees, for example. It then becomes the responsibility of governments, and regulators acting on their behalf, to ensure a market that charges a fair price for wireless service to the subscribers.

Spectrum cap is put in place when the market is young to ensure growth in competition.

Lifting the spectrum cap will generate a flurry of

strategies to eliminate the industry's inefficiencies. It will be a material positive for the wireless industry for two main reasons. One, it will promote faster roll-out of 3G. It will allow operators to expand their spectrum holdings, thus enabling them to begin offering advanced services without necessarily waiting for new 3G spectrum to be auctioned. Perhaps more importantly, lifting the cap could lead to a fresh round of Merger and Acquisition (M&A) activity to let the operators achieve scale economies through consolidation. While acquiring spectrum through M&A, the network operators pursue various spectrum strategies. These are described in the subsequent section.

The regulatory bodies must continuously rationalise the spectrum allocations so that the spectrum investment economics evolves with the industry dynamics. The alternative could be a disaster. There is a case when unclear spectrum regulations hindered the growth of the wireless industry. In December 2001, Latin America's first 3G auction was due to start, but it was postponed for a second time amid confusion amongst potential bidders (Biddlecombe, 2001a).

The delay will be damaging for all parties involved, especially the government, which will see the price of the licenses decrease every day as delay and uncertainty keep international investors and operators away. Not only this, the region will fall behind the rest of the world in providing consumers the access to mobile wireless data.

Another instrument the government could use to regulate the spectrum industry is ownership-stake caps. For strategic and economic reasons, national governments could cap the ownership stakes in domestic holdings by multi-national corporations. For example, Indian telecommunications rules currently cap the total foreign holding, portfolio and direct, in a local telecom company at 49 per cent. There have been mounting demands to increase the limit to attract the investments required to develop the sector (Reuters, 2001h). If the government felt it necessary to keep the cap for any strategic reason, then it may at least exempt foreign funds from the limit. This will provide domestic players access to crucial capital to grow their businesses in the capital-intensive telecommunications sector.

Through these primary means—spectrum caps, trading or transfer limitations, regulatory review and ownership stake caps-national governments have attempted to prevent spectrum from accumulating in the hands of one or two dominant operators. However, there are other instruments that regulatory bodies employ to drive spectrum market efficiencies. A few of these are described below.

Some countries (notably Australia) have employed a spectrum cap that applies only during government auctions. This spectrum cap then dissolves once the auction is completed.

In recently-held auctions, the national government of Hong Kong has experimented with what could be called royalty-based auctions. This scheme attempts to eliminate a few of the ills in the normal auctions. Under this regime, the service providers pay the auction amount in installments as they earn revenues by rolling out their networks and services.

National governments and regulatory bodies could spur innovation in the communications industry by encouraging regulations that promote the use of unlicensed spectrum, either directly or indirectly, as in the U.S. (Sabat, 2005b; CTIA Daily News, 2002a). However, critics are concerned that increased use of unlicensed spectrum could cause interference problems with licenses users' transmissions.

National governments and regulatory bodies could spur innovation in the communications industry by encouraging regulations that promote the use of unlicensed spectrum, either directly or indirectly, as in the U.S.

Whereas national governments and their representative bodies may be proactive in driving spectrum market efficiencies, the industry may encounter technical, financial and political complexities. For example, the roll out of E911 location-based services in the U.S. has been delayed due to these challenges (CTIA Daily News, 2002b).

With assistance from industry think-tanks, regulatory bodies may call for a new approach to the way communications spectrum is viewed, as well as used. There are developments that are giving rise to an "open spectrum" movement. In the U.S., these developments are changing how the FCC views the possibilities for allocating spectrum. Wireless carriers are interested in gaining more flexibility in using and trading the spectrum for which they paid billions. The open spectrum movement supports making available more unlicensed spectrum, as well as increased access to regulated spectrum bands. In October 2002, to overcome the tardy growth of mobile wireless industry in the U.S., its FCC called for an approach that harnesses the potential of smarter technologies to overcome scarcity challenges of wireless spectrum (CTIA Daily News, 2002c).

Upcoming wireless technologies are changing how electromagnetic spectrum is viewed, as well as used. These new radio technologies can use transmit voice and data communications using parts of the spectrum that are unlicensed or underused (CTIA Daily News, 2002d).

A few regulatory bodies are considering time factor for spectrum access. For example, the U.S. FCC is examining considering such regulations (CTIA Daily News, 2002c). Under such scenarios, licensees could rent certain spectrum bands during time periods when they are not in use. This would grant license holders the maximum flexibility to use—or allow others to use—the spectrum, within technical constraints, to provide any services demanded by the public. With this flexibility, service providers can be expected to move spectrum quickly to its highest and best use. However, it is difficult to underestimate the magnitude of the challenge in implementing such regulations. On the one hand, national governments have, over the years, leveraged their spectrum licensing authority to justify excessive intrusion into the minutiae of the marketplace. On the other hand, there is a legitimate role for government in preventing spectrum anarchy where the absence of rules increases interference and degrades the consumer experience. Any spectrum policy will also have to deal with the fact that while a few of the governments, such as the U.S., have not had a clear spectrum regulation policy, that has not inhibited it from making determinations upon which were based both corporate and consumer spending decisions.

The mobile wireless network operators' spectrum strategies

Within the given regulatory framework established for a region by national governments and their regulatory bodies, the network operators pursue multiple strategies to acquire spectrum rights to offer services in a particular region. First and foremost, mobile wireless operators may be *primary owners* of the spectrum in a given area. They may either build their own network or share network costs with other operators to offer wireless services. For example, to build its network in India, Bharti, plans to invest Rs. 15 billion (US$318.3 million) to roll out and upgrade mobile phone services under the nine regional licenses it has acquired (Reuters, 2001i). In the U.S., AT&T Wireless, which is currently upgrading its networks with GPRS, expects to spend US$2.5 billion on that technology upgrade (Reuters, 2001j). Verizon Wireless and Cingular Wireless have made similar network investment plans (Bourne, 2001a; Cox, 2002; Wrolstad, 2001).

There are many carriers that do not have the necessary capital to buy spectrum like Bharti, AT&T Wireless and Cingular did. Many national governments and operators, in an effort to reduce capital investments and contain operating costs, have been exploring multiple opportunities to enter into arrangements that save them spectrum investments. Governments have come up with changes in policy on infrastructure sharing, spectrum refiling and license length changes that may have the same net effect as a hand-back of money. The case of debt-laden Europe-based wireless operators and their respective governments' attempt to rectify the situation has been highlighted earlier in this paper.

A few network operators and service providers are increasingly looking at opportunities to form or extend re-sale and roaming agreements, to form affiliates, to increase their stakes in mobile operators, to secure revenues through alternate sources until they begin their 3G operations, and to share network build-outs, among other options. For example, Bell Mobility and TELUS Mobility have extended roaming and re-sale agreements in each other's territory (Paddon, 2001). TELUS also signed a similar agreement with Aliant Telecom Wireless (Biddlecombe, 2001b; Reuters, 2001k). In another development, Cingular is the first U.S. operator to offer GPRS live roaming between Cingular and T-Mobile USA networks (Total Telecom, 2001a). Similarly, in October 2001, AT&T Wireless agreed to acquire TeleCorp PCS (Reuters, 2001). In March 2003, TELUS Mobility and Aliant signed a roaming deal (RCR Wireless News, 2003a).

Roaming and re-sale agreements in Europe have given birth to *international operators.* For example, Denmark-based TDC Mobil and the U.K.-based Vodafone have agreed to co-operate in developing and marketing international roaming products and services to international travelers and corporate customers (Ransom, 2001a). Further, in January 2003, Vodafone extended its presence into Austria, Croatia and Slovenia via a marketing agreement with Mobilkom Austria (BWCS, 2003).

To benefit from roaming arrangements and expand coverage without investing in uncovered markets, major wireless carriers seek to form services marketing and distribution affiliations – the *affiliates strategy.* The larger partner benefits from the expansion of these relationships as they provide preferred networks for their subscribers into these new markets, lowering their reliance on roaming agreements with competing carriers and providing more favourable economics in return. For example, in the U.S. AT&T Wireless, Sprint PCS and Nextel have established affiliates (Hines *et al,* 2001; Hold, 2001; Makin & Lee, 2001; RCR Wireless News, 2003b; Reuters, 2002b & c). The affiliates, on their part, benefit

by operating under an established brand name, and by getting access to the major player's more extensive network and offer services in uncovered markets.

To build revenue and a customer base, a few greenfield 3G operators also form roaming agreements with currently-operating service providers. Greenfield 3G operators such as Hutchison 3G UK require such roaming deals as they allow them to provide a nationwide service before their own 3G infrastructure is complete. Hutchison 3G UK, the greenfield 3G mobile operator in the U.K. has agreed to commercial GSM roaming terms with OO_2 (formerly known as BT Cellnet), part of mmO_2 (Young, 2001a).

To build revenue and a customer base, a few greenfield 3G operators also form roaming agreements with currently-operating service providers.

The roaming partners live their purpose once the roaming operator builds its own network. The relationship between Wind and TIM as well as with Omnitel is a case in point (Roberts, 2001a).

Whereas primary owners of spectrum in a given region can pursue the above strategies, a company, however, does not always win license in a particular market. In such a case, it opts to acquire stakes in the auction-winner of targeted markets, as is the case with Telenor Mobile Communications (Ransom, 2001b).

To reduce their capital and operating costs, many operators also sign agreements to share the 3G network build-out costs. This is particularly useful for smaller operators and new entrants in the markets that already have well-established branded players. A few other agreements on sharing of network infrastructure build-out and wireless services provisioning are discussed in another paper (Sabat, 2005c).

There are also cases where a primary spectrum owner may have rights to operate in markets that are not contiguous. To provide a seamless wireless service to its subscriber base traveling through its unlicensed markets, this service provider may have to enter into roaming agreements with other operators, which has been described earlier in the paper. Alternatively, because roaming agreements are uneconomical to the operator paying roaming charges, it is on the look out to *fill the gaps* by acquiring additional spectrum from the spectrum holder of the market. This spectrum holder could be national governments, another operator, or a spectrum *reseller.*

Primary spectrum owner may have rights to operate in markets that are not contiguous.

Operators bid in the auctions held by the national governments to fill the gaps in their markets. For example, the major carriers in the U.S. bid US$17 billion approximately for 1900 MHz spectrum to fill holes in their markets when it was re-auctioned in 2000-01 (Carvalho *et al,* 2001a).

Alternatively, operators could merge, or acquire either another operator or certain of its operations. For example, Indian mobile phone giants BPL Communications and Birla-AT&T-Tata have planned to merge, creating the country's largest cellular company, which is valued by the partners at more than US$2 billion (Reuters, 2001i & n).

The consolidation dynamics are more frequent in the U.S. The U.S. wireless industry is unusual because historical Federal Communications Commission (FCC) spectrum allocations created a 'patchwork quilt' of coverage and technology. The spectrum allocation process and the sheer size of the U.S. geography created numerous regional and local operators. In Europe and Asia, the story is very different, which is understandable given the fact that Sweden has as many people as New Jersey, or Spain as many as California. Only through consolidation have U.S. companies taken on a more "national" footprint. However, virtually no wireless operator has spectrum licenses covering 100% of the geography and population of the U.S. (Carvalho, Amaro & Lundberg, 2001). Thus, the so-called "national" wireless operators really are not. Coverage maps of Verizon Wireless, AT&T Wireless, and Cingular are still full of many holes. While many key areas are covered, there are still gaps. Wireless network operators seeking to gain scale and scope have necessarily had to turn to M&A as a way to increase the size of their businesses.

Since most of the large U.S. carriers, such as Verizon Wireless, Cingular Wireless, AT&T Wireless, ALLTEL, had their origin in the cellular business, most potential acquisitions involve a great deal of cellular Rural Statistical Areas (RSAs), and hence, bump into the ongoing dual-ownership waiver requirement. Companies could get creative and create separate rural subsidiaries, or even spin-offs, to drive transactions in Metropolitan Statistical Areas (MSAs). An example of

this is CenturyTel selling its wireless business in 2002 to ALLTEL. For pure-play Personal Communication Services (PCS) operators in the U.S., such as Sprint PCS, VoiceStream, Leap Wireless, Triton PCS and Northcoast Communications, there is a more near-term opportunity to rationalize spectrum positions by selling non-core licenses to more needy carriers. Since the spectrum cap goes away in essentially one-year, numerous, and previously unthought-of, transactions could emerge. Such moves toward consolidation and rationalization of licenses would likely boost long-term profit margins and ultimately be a plus to equity values.

The inability to fund capex and compete with national carriers can prompt regional operators to merge with larger carriers. For example, in October 2000, TeleCorp PCS agreed to buy Tritel for US$1.1 billion. Then, in October 2001, AT&T Wireless agreed to acquire the 77% of TeleCorp PCS it did not already own for US$2.4 billion (Reuters, 2001l).

The mobile wireless industry dynamics in the U.S. is fraught with consolidation activities. In an agreement to buy spectrum from Leap Wireless, Cingular Wireless purchased rights for 15 MHz of spectrum in July 2001 to expand its coverage area (Rickard & Hold, 2001). Leap also sold four licenses to Skagit Wireless (Reuters, 2002d). Verizon Wireless has also pursued this strategy (Hall, 2000; AFX News). In December 2001, US Unwired, the largest Sprint PCS affiliate, and IWO Holdings, Inc., both Sprint PCS network partners, entered into a definitive agreement under which US Unwired will acquire all of the outstanding shares of IWO Holdings for US$ 459M in stock (Hold, 2001; Reuters, 2002c). In February 2002, US Unwired bought Georgia PCS Management, another Sprint PCS affiliate, in a transaction valued at approximately US$90.4 million (Reuters, 2002b). In January 2003, Nextel Communications bought NeoWorld Communications from private equity firm Boston Millenia Partners (CTIA Daily News, 2002i & 2003b). ALLTEL Corporation has agreed to purchase wireless properties in southern Mississippi from Cellular XL Associates (CTIA Daily News, 2002g).

In a spectrum reselling agreement, the major U.S. mobile telephone carriers have reached a deal with NextWave Telecom that calls for Verizon and companies controlled by Cingular, AT&T Wireless and T-Mobile USA to pay US$15.8 billion to end a five-year dispute over the disputed spectrum (Stern, 2001; Reuters, 2001g).

These consolidation activities are a natural outcome of rulings to lift spectrum cap because with fewer regulatory hindrances, the national operators may begin to consolidate – both among themselves and by acquiring regional and rural operators. After consolidation, companies could also be encouraged to operate separate subsidiaries, or even spin-offs, for efficient management of culturally-different acquisitions, and to drive transactions in newly-acquired markets. Larger companies can generate scale economies that are not possible for smaller players. These companies can use their large size to leverage marketing and operational expenses among contiguous footprints and allow for equipment and long-distance purchasing power.

Further, by bringing roaming "on network," operators can significantly boost gross profitability and enhance the operation attractiveness of national "one-rate" plans. Also, buying networks that are up and running is far easier than building "greenfield" spectrum. Larger footprints tend to attract more users, even if many users stay in their home markets most of the time. By owning larger footprints, carriers can craft more economical price plans, and also more effectively target the enterprise market. Wider footprints also present the ability to provide consistent quality and feature sets. An acquisition to increase footprint can also potentially eliminate an in-market competitor.

Moreover, larger companies tend to have better access to capital. More spectrum licenses and larger cash flows gained through acquisition tend to support more debt financing by increasing credit worthiness.

Companies also face the following barriers that restrict national and regional consolidation. There are certain potential business combinations (especially among national carriers) that would not, in all likelihood, make it through the anti-trust regulatory reviews. Another barrier to certain combinations is the technology used by the various operators. Further, leverage (Debt/Earnings before income tax, depreciation and amortization) and cash liquidity may limit consolidation between independent companies, pushing consolidation to nationals/regionals buying into independents. Furthermore, the national governments may still have to retain certain regulatory restrictions to aid efficient management of scarce spectrum bandwidth.

More spectrum licenses and larger cash flows gained through acquisition tend to support more debt financing by increasing credit worthiness.

In addition to the general barriers to consolidation discussed above, particular challenges facing the rural and regional independent operators can be seen. First, in most parts of the world, a big challenge for the

independents in future consolidation is that national operator's network holes will need to be filled market by market. As ownership is so disparate at this point, a single buyer does not have to look only to the acquisition of an entire company. Buyers can be selective, choosing only specific markets, and may have stronger negotiating leverage than sellers. The second challenge for independents is overlap: to be purchased outright, there might be significant POPs that overlap with the buyer and thus need to be sold, complicating the transaction. Furthermore, cross-ownership rules might still limit a single entity to own certain licenses.

As the subscribers of roaming partners, over time, may not carry dual-band, dual-mode phones, technology is important. Hence, they would not be able to roam onto the rural and regional networks unless those networks are upgraded to digital. Also, whereas not necessarily important for the independent pure-play wireless companies, the existence of wireline operations alongside wireless operations may make wireless consolidation more difficult for some operators. Last, the independent operators are not the only sources of wireless spectrum in the market. There are many players that currently control raw spectrum, but have not built out networks.

If an operator does not own spectrum in a particular region, and also does not have liquidity to buy operations or companies with established networks in uncovered markets, it will trade some spectrum to improve its position in certain markets. In such a case and if carriers do not need all of their licenses, they either *pool and share* the spectrum to operate in the uncovered markets, while retaining spectrum ownership, or *swap* spectrum with another operator to own contiguous spectrum that frees the operator from expensive roaming arrangements with other operators.

In pool and share agreements, partner companies pool their spectrum resources in specified markets and provide access to their existing spectrum. In an agreement to pool and share spectrum, Deutsche Telekom's U.S. wireless unit operating under T-Mobile's umbrella, VoiceStream Wireless, and Cingular Wireless have formed a managed 50:50 U.S. venture to share GSM networks, and save equipment and operating costs (Associated Press / AFX News, 2001; Atlanta Business Chronicle, 2001). In January 2002, Cingular and AT&T Wireless announced a joint venture to share the cost for the build-out of a 'new' GSM/GPRS overlay (Noguchi, 2002; Reuters, 2002f).

In a spectrum swapping arrangement in November 2000, Cingular Wireless and VoiceStream Wireless agreed to exchange spectrum licenses covering about 35 million subscribers, and a quarter of the U.S. population, by mid-2001 (Reuters, 2000b). Similarly, in November 2000, AT&T Wireless struck a deal with Sprint PCS to exchange some advanced wireless service territories in markets around the country. In a similar agreement in October 2002, Dobson Communications Corporation and AT&T Wireless signed a letter of intent to exchange Dobson's two remaining wireless properties in California, U.S., and two of AT&T Wireless' properties in Alaska, U.S. In another spectrum swapping offer, Nextel Communications has proposed an exchange of wireless airwaves to eliminate interference that has disrupted radio communications for dozens of police and fire departments across the U.S. (Davidson, 2001; Brewin, 2002; CTIA Daily News, 2003c). In April 2002, Leap agreed to sell six operating licenses to AT&T Wireless in exchange for a 10 MHz license in New York (Reuters, 2002d). In December 2002, AT&T Wireless and Cingular Wireless agreed to exchange wireless licenses in some U.S. markets (CTIA Daily News, 2002h).

The above spectrum strategies are a natural outcome of industry economics. However, national governments may enforce regulations for the development of cellular services in a country. For example, Indian telecom rules bar a single company from owning two licenses to offer services in one state (Reuters, 2001n). This will preclude the emergence of a monopoly market in these regions, and will ensure services are reasonably priced by competitive market.

Further, to promote development in certain regions, the government may stipulate certain conditions to be met before an operator can own spectrum rights and operate wireless services. Examples of this are regulations for the tribal areas in the U.S. that are open only to operators qualifying for it; the operators also benefit from tribal land credits. The regulatory bodies are entrusted to apply these special regulatory powers in these regions to maintain fair market conditions. For example, in the U.S., when TeleCorp acquired Tritel in October 2000, the newly combined company had to pay the federal government to make up for some bidding credits Tritel received as a small company when it acquired certain wireless licenses (Reuters, 2000a). In these tribal areas, national carriers may, however, opt to operate through *surrogate* players such as AT&T Wireless through Alaska Native Wireless, Cingular through Salmon PCS, Sprint PCS through SVC BidCo, Dobson through DCC PCS, US Cellular through Black Crow Wireless, and VoiceStream through Cook Inlet (Condon *et al,* 2001).

The surrogate players act in unison with their parent players. For example, in Canada's 3G auction, a numbered company backed by the U.S.-based Sprint Corporation filed for the auction, but dropped out of the

race close to the auction date when Sprint PCS wanted it to (Karleff, 2001).

Business implications for stakeholders

An understanding of how spectrum is distributed and how its use is regulated will help regulatory bodies, network operators and other industry stakeholders to make appropriate investments in the spectrum industry and earn adequate ROIs. This is especially important when the telecommunications industry is experiencing difficult market conditions. Understanding the spectrum market's macro and micro drivers and their impact on the industry's liquidity can help the industry to come out of the current slowdown, and also to make future investments that earn them adequate ROIs.

Understanding the spectrum market's macro and micro drivers and their impact on the industry's liquidity can help the industry to come out of the current slowdown.

The treatise on spectrum strategies will help network operators become aware about each other's spectrum strategies. Operators can, then, judiciously invest adequate amount in spectrum auctions, not over-bid, and bid for the ones they need to increase coverage and capacity. The treatise also gives the operators an idea of the feasibility of different strategies across the world under different spectrum regulatory regimes.

From the stated business world examples, auction-framers can obtain an integrative view of the impact of spectrum policies on the industry's stakeholders across the world. The framers of spectrum distribution mechanisms can, then, structure their instruments in order that the outcome is a result of free market policies, and the industry benefit from economic efficiency associated with such an instrument. An insight into the designs and diligence in constructing economically efficient instruments designed for a country's specific regulatory environment will save the industry from incurring the opportunity costs of poorly-designed auctions.

Through an understanding of various spectrum strategies, the investment analyst community, carrier associations, spectrum industry investors, and other telecom representatives can lobby with the government for appropriate spectrum policies. National governments and their regulatory bodies can also look at the impact of regulatory instruments on the carriers' manoeuvers in response to their regulations. Further, they can frame regulations that would allow more efficient allocation and utilisation of spectrum. A good example of this is the instrument of combinatorial bidding regulated by the FCC in the U.S. that can help the emergence of true national carriers. National governments could also provide directives and incentives to operators and equipment vendors to develop networks that are more spectrally-efficient, as the new spectrum policy in the U.S. does.

Conclusion

Wireless being a young industry in most parts of the world, the economics of mobile wireless, including spectrum investment economics, is yet to take firm root. This is especially true in the spectrum industry, which by its very nature as a scarce commodity does not involve frequent investments. Importantly, as regulatory bodies become more adept at regulating spectrum industry through appropriate regulations, a few of these strategies may not be practiced by operators. Further, a multitude of cultural intricacies also affect the spectrum rulings in different regions and even within different countries. Sometimes, national governments' populist measures defy logic of spectrum economics. Further, following the Law of Disruption propounded by Downes and Mui (1998), whereas customers and market may cause certain technological changes to occur exponentially, adoption of new technologies by social, political and economic systems may occur incrementally, lagging behind the technological change cycles. Therefore, whereas the market dynamics may demand certain changes to occur quickly, its adoption may be slower and end up testing the patience of mobile industry's stakeholders. That said, whereas each region may differ, this paper discussed a good way to look at spectrum distribution and regulation when thinking about mobile wireless market dynamics.

References

AFX News (2001a). "Spanish 3G network sharing talks near agreement", **mbusiness,** October 8.

AFX News (2001b). Verizon Wireless to acquire part of Dobson Communications operations for 465 million USD, November 1.

Associated Press / AFX News (2001). VoiceStream, Cingular joint venture to share GSM networks, mbusiness, October 15.

Biddlecombe, E. (2001a). 'Unique' Uruguayan mobile auction delayed again, Total Telecom, December 11.

Biddlecombe, E. (2001b). "Canada's rivals agree to share mobile networks", Total Telecom, October 18.

Bourne, E. (2001a). "Ericsson bags largest share of Cingular contract", Total Telecom, December 3.

Bourne, E. (2001b). "BT, Deutsche Telekom set terms for 3G cooperation", Total Telecom, September 21.

Brewin, B. (2002). "Nextel spectrum plan riles private wireless users", Computerworld, January 18.

Carvalho, L., Amaro, S., and Lundberg, G. (2001). "The FCC clears the air", Morgan Stanley Dean Witter, November 9.

Carvalho, L., Amaro, S., Attar, M., and Lundberg, G. (2001a). "Wireless services: bridge over troubled markets", **Morgan Stanley Dean Witter,** June 19, p. 54.

Carvalho, L., Amaro, S., Attar, M., and Lundberg, G. (2001b). "Wireless services: affiliated we stand! Morgan Stanley Dean Witter", October 5.

Condon, K., Isherwood, S., Rindos, M., and Binder, L. (2001). "North American wireless weekly", UBS Warburg, January, p. 11.

Cox, J. (2002). "Verizon Wireless to spend $900 Mln for upgrades in U.S. Midwest", Bloomberg, January 7.

Davidson, P. (2001). "Nextel proposes swap to clear air for police, fire calls", USA Today, November 26.

Downes, L., and Chunka, M. (1998). "Unleashing the Killer App: Digital Strategies for Market Dominance", Harvard Business School Press: Boston, pp. 28-32.

Hall, J. (2000). "U.S. carriers seek spectrum to fill gaps", Total Telecom, November 13.

Hines, J.L., Fifer, B., and Avery, C. H. (2001). "Nextel Partners", Deutsche Bank, January 23.

Hold, E. (2001). "US Unwired buys into the affiliate race, acquiring IWO", Current Analysis, December 21.

Karleff, I. (2001). "Canadian spectrum auction bags C$1.5 billion", Total Telecom, February 2.

Larsen, C., Simcik, G., and Moorman, J. (2001). "Wireless telecom industry", Prudential Securities, April 4.

Lundberg, G., and Carvalho, L. (2001). "Wireless data services: state of the union", Morgan Stanley Dean Witter, June 20, p. 3.

Makin, D., and Lee, J. (2001). "Nextel Communications, Inc., Kaufmann Brothers", March 19.

Menon, S. (2001). "Bharti sweeps Indian mobile license auction", Total Telecom, July 31.

Mitchelson, D.D., and Sarma, N. (2001). "Tower signals: sharing just a distraction-3G rollouts are the main event", Deutsche Bank, June 19, p. 10.

Mouawad, J. (2001). "France may allow sharing of UMTS phone networks", Bloomberg, September 7.

Noguchi, Y. (2002). "Cingular, AT&T Wireless team on digital network", Washington Post, January 29.

Paddon, D. (2001). "Bell Mobility, Telus Mobility to save $1 billion by sharing networks", National Post, October 18.

Ransom, M. (2001a). "TDC Mobiel roams with Vodafone", Current Analysis, December 17.

Richardson, A. (2001). "Ireland launches competition for 3G licences", Total Telecom, December 18.

Rickard, J. (2001). "Déjà vu all over again: Verizon Wireless prices Price Communications", Current Analysis, December 20.

Rickard, J., and Hold, E., (2001). "Cingular leaps into Winter Olympics with spectrum purchase", Current Analysis, July 31.

Sabat, H.K. (2002a). "The mobile wireless supply chain", Productivity, 42(4), January-March, pp. 550-563.

Sabat, H.K. (2002b). "The evolving mobile wireless value chain and market structure", Telecommunications Policy, Special issue on The Telecom Value Chain and Market Structure, 26(9-10), pp. 505-535.

Sabat, H.K. (2002c). "The capital investment economics of mobile wireless", IIMB Management Review, 14(3), September, pp. 17-31.

Sabat, H.K. (2003). "The economics of mobile wireless spectrum: ownership, distribution and regulation", IIMB Management Review, 14(4), December, pp. 31-43.

Sabat, H.K. (2005a). "The business economics of the mobile wireless industry", IIMB Management Review, forthcoming.

Sabat, H.K. (2005b). "The economics of mobile wireless spectrum: Challenges in the distribution and regulation of in the U.S. for the emergence of a competitive mobile wireless service", IIMB Management Review, forthcoming.

Sabat, H.K. (2005c). "The network sharing economics of the mobile wireless industry", forthcoming.

Stern, C. (2001). "NextWave reaches deal over disputed spectrum", The Washington Post, October 16.

Stevenson, R. (2001). "Low-key launch for DoCoMo 3G phones", Total Telecom", October 1.

Wrolstad, J. (2001). "Cingular inks $3.5B Next-Gen network deals", Wireless NewsFactor, December 3.

Young, A. (2001a). "Hutchison 3G UK in 2G roaming deal with Cellnet", Total Telecom, December 10.

Young, A. (2001b). "Sweden's 3GIS awards 3G backbone deal to Skanova", Total Telecom, October 19.

Other sources of information:

BWCS (www.bwcs.com): 2002a-e, 2003

CTIA Daily News (www.wow-com.com): 2002a-1, 2003a-c

RCR Wireless News (www.rcrnews.com): 2002a-b, 2003a-b

Reuters (www.reuters.com): 2000a-c, 2001a-q, 2002a-f

Total Telecom (www.totaltele.com): 2001a, 2001b, 2002.

□

Feature

Linking Knowledge & Risk Management: Controlling the Information Flood

C. Vijaya

Knowledge management and enterprise risk management are needed to control the flood of raw information. Human intermediaries, like internal audit, can help reduce bottlenecks in the system overall. This paper looks at some of the ways in which one can identify meaningful business information from the huge quantities of data that threaten to overwhelm today's business organizations.

C. Vijaya is a Faculty Member, ICM, Bhubaneswar

The mass of information generated by humanity is growing beyond all comprehension. Between one and two billion gigabytes of unique information is produced every year, about 250 megabytes for every man, woman and child on earth, according to a study by the University of California at Berkeley. Within the next three years, the world will generate as much information as it has in all the preceding years of human history. But the brain's capacity to absorb information remains essentially unchanged.

The effects on the business psyche are pervasive and alarming. Mental health professionals have coined the term Information Fatigue Syndrome (IFS) to cover the array of symptoms exhibited by overwhelmed workers. Symptoms include:

- Hurry sickness—the sense that time is racing and that one must rush to keep pace.
- Plugged-in compulsion—the constant need to be in touch with the information grid by checking e-mail, voicemail and the Internet.
- Habituation—the trance-like state of mind reached when the overloaded brain powers down.

The effects on business leaders' decision-making abilities are also disturbing. A Reuters study found that 40% of executives surveyed believed their ability to make important decisions was hindered by an overabundance of information. Half the respondents said they were unable to cope with the volume of information they were receiving—yet two-thirds said they wanted even more information. The study points to a paradox: Despite the huge volume of information executives receive, they are still not getting what they need.

What they need is the knowledge to run a superior business. But how this can be acquired is a pertinent question.

The Search Within

Data, information and knowledge are related concepts. Data is the basic building block of communication, while information is data placed in a meaningful context. For example, "23%" is a piece of data without meaning, but "fixed annuity sales increased by 23% in the second quarter in 2001" conveys some limited information. An understanding of the complex reasons underlying the annuity sales trend represents knowledge.

Knowledge is information that has been processed, interpreted and linked to other relevant pieces of information by a person based on his or her particular set of experiences. Even when two people with similar backgrounds access the same information, the knowledge each takes away is unique. When someone uses information to achieve a business goal, that person is creating value by putting his or her knowledge to work.

The root cause of information overload is that most of the information received in today's complex business environment is raw and unstructured. People fear they may miss something critical, so all information must be examined. Increasing the amount of unstructured information available to everyone within an organization may increase the chances of stumbling on to important information, but it also increases the amount of time spent processing information to determine its relevance.

The first stage of the information revolution has produced vast quantities of information, but the next stage will be much more focused on quality—the meaning and purpose of information. Increasing the amount of information available does not increase the knowledge needed to improve productivity or take advantage of opportunities.

Such efforts have backfired, because they have simply increased the size of the haystack people need to search in to find the needle of information they require. The relevance of all business information is directly linked to business goals. Getting the right information to the right people at the right time is the ideal scenario, but all three elements involve value judgments. What is the right information and where does it reside? Who are the people best placed to make use of the information? When do they need to have it so they can act on it?

For many large, complex corporations with multiple sites, a formal knowledge management system is needed to control the flood of information on one hand, and to ensure lack of information doesn't result in duplicated efforts on the other. A well-organized system is also required to ensure individuals carry out their roles using the most accurate, relevant and up-to-date information available. Technology may offer some relief, but fundamental management and strategic issues need to be settled first.

As many organizations have discovered, a large-scale company intranet can become an expensive waste of time if people are not given the cues and incentives to use it and if no one is responsible for maintaining its content.

An infrastructure that weaves together policy, process and technology is essential to manage and direct the flow of information. This flow is best supported by embedding knowledge management guidance and criteria into every facet of an organization's operations and methodologies. It means identifying and incorporating explicit references to the tools and tenets of knowledge management in sales, product development, marketing, human resources, internal audit, finance, information technology and training.

Time-pressured, career-oriented staff need to be encouraged to share their knowledge and expertise by designing incentives and rewards into the career-development and performance appraisal processes. The careful and deliberate integration of knowledge management criteria – content capture, quality assurance, categorizing and storage, dissemination, maintenance – guarantees top-of-mind thinking, ensures broad acceptance and compliance, and cultivates an informed and responsive knowledge-sharing culture.

Staff need to be encouraged to share their knowledge and expertise by designing incentives and rewards into the career-development and performance appraisal processes.

Few business leaders need to be convinced of the value of sharing information across their business. Exchanging views with like-minded colleagues about common issues often results in the realization that someone, somewhere has encountered and solved similar problems within the organization. But the days of trading stories are long gone.

The Quest Beyond

Knowing what is going on in the external business environment is also crucial to corporate mental health. Many business processes cannot operate effectively without external feeds of business informa-

tion. Even the more internally focused functions need external information.

Looking outside the confines of the organization can also provide useful knowledge about industry best practices. In a low-growth economy, working smarter through process improvement is a key success factor. Industry benchmarks are also a good way of pinpointing areas that can be streamlined.

Looking outside one's industry sector for insight can also result in creative leaps of innovation instead of incremental improvements. If an average company tries to emulate the process of a world-class company in its sector, it can, at best, catch up to achieve a similar performance level.

To surpass it, a fresh approach to the problem is needed. Looking to industry sectors where a particular process is central, can yield qualitative improvement. Many companies are bound by the notion that their businesses are unique, but few management experts share this view.

Process redesign may improve competitiveness, but it also introduces new risks that a company may not have encountered in the past. Most companies already have a full complement of techniques for dealing with known risks to ensure that the things that have gone wrong in the past never happen again. Where companies are most likely to stumble is where knowledge is in short supply: new risks with a low probability of occurrence.

The Soft Underbelly

Though good knowledge management points organizations to better practices and new business opportunities, increased access to information does not necessarily minimise risk, and may even increase it. No analysis of business opportunity can proceed without considering its twin, business risk. "How can I find out what I don't know about risk?" is an unsettling question, as it is without boundary.

The question must nevertheless be addressed to ensure the business's survival. In these unforgiving economic times, investors, customers and regulators have raised risk management requirements to new heights. The market's perception is that a company's ability to manage its risks is as important as its ability to profit from business opportunity.

The ability to identify and monitor potential threats, minimize their impact and communicate these capabilities explicitly can contribute to shareholder value by sending the message that those investments and assets are as safe as humanly possible.

Knowledge management helps provide the information an organization needs to achieve its primary goals of managing both the upside and the downside. Risk management and knowledge management are linked: The purpose of all business information, ultimately, is to maximise value and minimise risk.

On the upside, all organizations need to know ways and means to increase productivity by accelerating innovation, reducing time to market and improving customer service. On the downside, all organizations need to know and address the risks of conducting their businesses.

So, a properly implemented knowledge management system needs to capture information about both opportunity and risk. As with systems that track information about opportunities, risk management systems need both internal and external information feeds, since risks may manifest themselves as a result of inefficient internal management, or, as recent press coverage has made painfully clear, they may reside in the external environment.

Effective knowledge sharing allows an organization's people to actively manage risk by organizing, categorizing and monitoring risks as they relate to their functional roles. Knowledge sharing of risks across functions is a trickier proposition, since most companies' functional areas develop their own information silos.

Effective knowledge sharing allows an organization's people to actively manage risk.

Risk management experts agree that it is in the interfaces across functions that the greatest risks reside, because people in functional silos are not aware of the impact of their processes on other areas, or the cumulative impact on the enterprise. How an organization manages knowledge sharing across silos has a major impact on the overall effectiveness of enterprise-wide risk management.

For example, if a new process is introduced, the originator is typically charged with identifying the risks and designing controls to address them. Determining the impact on other areas requires serious cross-functional collaboration. Should the proposed controls be distributed to a "community of interest"?

How can this community be identified when people who need to be involved may be scattered in different divisions, geographies or business units? What degree of validation is needed to ensure all risks have been considered and all interested parties find the controls acceptable? Should the proposed controls be benchmarked against external standards?

How much effort should be put into the validation process to ensure efforts are sufficient but not excessive? The relationships of risks across the organization can only be identified and managed, and effective enterprise-wide risk management can only occur, when the organization shares risk and control knowledge systematically across its functions and departments.

Most companies tend to accrete their control systems, whether on the financial, production or sales side. So, over time, you get hundreds of these systems. If you ask companies how many control systems they have, they don't know. If you ask them how much they're spending on control, they say, "We don't add it up like that." If you ask them to rank their control systems from most to least cost-effective and then cut out the 20% at the bottom, they can't.

An Untapped Resource

In most organizations, risk managers identify the risks and develop controls to address them within their functional areas, and internal audit assesses the efficiency and effectiveness of these controls. For internal audit, distilling information about the nature of business risks, how they are managed and to what extent they impact the organization's business processes and strategic goals, is a fundamental competency.

Few corporate functions have the license, purview and perspective to view an organization from such a broad vantage point. Because of this role, internal auditors are uniquely positioned to share relevant information throughout the organization, thereby increasing the company's ability to effectively manage its risks.

However, business units often can't see the big risk picture and so can't decide which risks warrant the greatest attention and resources. It is human nature to focus on known risks and to develop responses from that perspective. People with insurance expertise tend to focus on insurable risk; actuaries and statisticians prefer to quantify risk; strategists focus on business redesign; finance experts talk about transferring risk to the capital markets; and so on.

Each perspective is valid in a limited way, but fails to fully address all of the risk management issues a company must address. In its business advisory role, internal audit is one of the few areas that are well placed to see the big picture.

But the internal audit's perspective, while valuable, is only one component in a broader business endeavour. There is no one area or field of knowledge that is sufficient to address all the real-world problems of risk management. Information sharing and coordination within the context of a formal knowledge management system are needed to fulfill an enterprise's risk management goals.

Business generalists, such as internal auditors, who have the capacity to synthesize information and apply problem-solving techniques, can help identify critical systemic risks without getting bogged down by the vast quantities of information available in a particular area.

But effective enterprise risk management requires all people, processes and technology working together to sift, find and link relevant risk information. The volume of information overwhelming most corporations is set to increase in the future. The challenge for business leaders is to reduce the noise in the system, so that managers can manage the business instead of managing a flood of disjointed information. □

A competitive world has two possibilities for you. You can lose. Or, if you want to win, you can change.

– Lester C. Thurow

Feature

Agility of Supply Chains: A Study of Sectoral Dissimilarities

Ashish Agarwal, Ravi Shankar & M.K. Tiwari

Agility, the fundamental characteristics of a supply chain, is essential for survival in a turbulent and volatile market. Agility is often linked to market sensitiveness, centralized and collaboration planning and use of IT tools. This paper surveys the difference in the perception of supply chain managers of three sectors of Indian manufacturing firms towards issues related to agility. Results indicate a significant difference in the perception of original equipment manufacturers and suppliers towards these issues.

Ashish Agarwal and Ravi Shankar are lecturers at the Department of Management Studies, Indian Institute of Technology Delhi and M.K. Tiwari is lecturer at the Department of Manufacturing Engineering, National Institute of Forge and Foundry Technology, Ranchi.

Supply chain management (SCM) helps firms in integrating their business by collaborating with other value chain partners to meet the unpredictable demands of the end-user. An integrated supply chain or seamless supply, engineered to cope with uncertainty can profitably satisfy customer demand, while non-integrated manufacturing processes, non-integrated distribution process and poor relationships with suppliers and customers lead to business failure for trading firms.

In the era of time-based competition, the supply chain must have the ability to meet the demands of customers for shorter delivery times and to synchronize supply during the rise and fall of demand (Pati et al., 2003). To have this flexibility the supply chain must be responsive to the needs of the market. Responsiveness requires speed and a high-level of manoeuverability, also known as agility. Agility is business-wide capabilities that embrace organisational structures, information systems and in particular, mindsets (Christopher 2000). Agility means using market knowledge and virtual corporation to exploit profitable opportunities in a volatile marketplace (Mason-Jones and Towill 1999). Christopher (2000a) has identified a number of characteristics that a supply chain must have in order to be "truly agile".

The supply chain must have the ability to meet the demands of customers for shorter delivery times and to synchronize supply during the rise and fall of demand.

In literature, various frameworks for improving the agility of supply chains have been suggested. For example Bal et al., (1999) proposes a virtual teaming model for introducing agility in a supply chain. Tolone

Trust among trading partners in inter-organisational relationships improves communication and dialogue and creates common strategic visions.

Research Methodology

A study has been conducted to ascertain the relationship between the perceptions of OEMs and suppliers towards issues of the agility of a supply chain. For this purpose, a questionnaire was framed and administered among the manufacturers and suppliers of auto, fast moving consumer goods, and the electrical and electronics goods sectors.

Instrument Development

The questionnaire was designed on a five-point Likert scale. Respondents were asked to indicate their perception towards the influence of issues like lead-time reduction, total cycle time compression, information distortion among supply chain partners, cross functional training, investment in high technology, investment in the MRP system, and trust among trading partners in their supply chains. On the Likert scale, 1 stands for the least important and 5 for the most important.

Structure and Content Validation

The questionnaire was tested for two main types of validity (i) content validity, and (ii) construct validity. Content validity primarily depends on an appeal to the propriety of content and the way it is presented (Nunally, 1978a). The instrument developed in this study demonstrates the content validity as the selection of measurement items was based on both, an exhaustive review of the literature and detailed evaluations by academicians and practicing managers during pre-testing. The construct validity was verified by factor analysis. All the items in the questionnaire related to barriers loaded with a minimum factor loading of 0.49. This is in agreement with Kim and Mueller (1978) who suggested the use of only those items, which have a factor loading of more than 0.40.

Target Sectors for Survey

Three sectors from the manufacturing industries were selected for the questionnaire. These were (i) auto (AUTO), (ii) fast moving consumer goods (FMCG), and (iii) electrical and electronic goods (ELECT). In these sectors, the auto sector is seen as a flagship bearer, frequently regarded as a barometer measuring the current wealth of a nation's economy. The extreme complexities and long lead-times of automobile manufacturing make it an ideal case for the study of supply chain management (Jharkharia and Shankar, 2004a). Industries in the FMCG sector put relatively more emphasis on downstream as compared to upstream of the supply chain. Industries in the ELECT sector and in the AUTO sector put equal emphasis on upstream as well as on downstream of the supply chain (Sahay, 2003). Therefore, in the present study these three sectors have been included in order to analyze their perceptions towards issues concerning the agility of a supply chain.

Survey Administration

The postal survey method was used for the administration of the survey. The Indian experience of mailed surveys using random sample from an industrial database has not been encouraging. Therefore, to obtain a high response rate, convenience-randomized sampling was used in this survey. The sample was selected from the Directory of ISO 9000 companies (2000) and India's 500 largest wealth creator companies (Gandhok et al., 2002).

Data Analysis and Testing of Hypotheses

Non-Response Bias and the Reliability of the Survey

One test for non-response bias is to compare the difference between the early and the late respondents of the survey on some variables of interest (Lambert and Harrington, 1990). Therefore, comparing those responses which were received without a reminder, or after one reminder versus the responses, which were received after sending two or more reminders, can provide an indication of non-response bias. The results from t-tests suggest that early responses do not significantly differ from the late responses. Cronbach's coefficient (a) was calculated to test the reliability and internal consistency of the responses. Cronbach's coefficient, having a value of more than 0.5 is considered adequate for such exploratory work (Nunally, 1978b). The value of a in this study was found to be 0.79 for issues in agility of a supply chain. It implies that there is a high degree of internal consistency in the responses to the questionnaire.

There is a high degree of internal consistency in the responses to the questionnaire.

(2000) has supported the role of real time and asynchronous collaboration technology for allowing manufacturers to increase their supply chain agility. Prater et al., (2001) has used case studies to show how firms have successfully made a tradeoff between vulnerability and supply chain agility. Svensson (2001) has stated that lean, responsive, and agile supply chains require satisfactory or high levels of perceived trust of companies towards suppliers and customers. Power et al., (2001) have identified some of the issues critical for successful agile organisations in managing their supply chains. Stratton and Warburton (2003) have explored the role of inventory and capacity in developing agile supply chain for an apparel manufacturer. Yusuf et al., (2003) have presented a conceptual model for assessing the capability of an agile supply chain, which consists of four dimensions: value chain practice, competitive objectives, impact of change drivers, and business performance. Lau et al., (2003) proposes an infrastructural framework for the design and development of an agile supply chain system, which is characterized by its ability to cope with unpredictable changes related to the management of suppliers and flow of parts within the value chain of the entire production network.

In the literature, there were a few empirical studies analyzing the issues responsible for supply chain agility, but there is hardly any empirical study that analyzes the difference in the perception of original equipment manufacturers (OEM) and suppliers towards supply chain agility. Therefore there is a need to develop a generally applicable framework, which is capable of analyzing the issues affecting supply chain agility.

The main objectives of this paper are:

- to formulate some hypotheses relating to the agility of a supply chain so that management can develop strategies for improving the agility of their supply chain,
- to test the validity of these hypotheses and establish the relative importance of the issues in influencing supply chain agility, and
- to discuss the implications of the study for future research.

Issues in Agility of A Supply Chain

The important characteristics that make a supply chain agile in nature are market sensitivity, process integration, information sharing, and networking (Christopher 2000a) (Fig. 1).

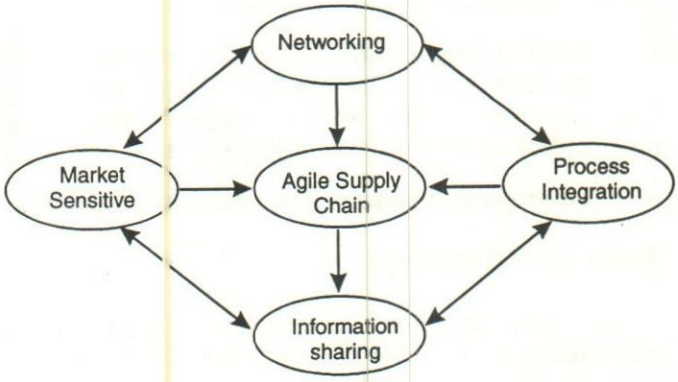


Fig. 1. A framework for agile supply chain

By market sensitivity we mean that the supply chain is capable of reading and responding to real demand (Christopher and Towill 2001). This requires lead-time reduction in terms of flow of information and material (Naylor et al., 1999; Jayaram et al., 1999). Slashing of material flow lead-time and information and material (Naylor et al., 1999; Jayaram et al., 1999). Slashing of material flow lead-time and information flow lead-time would result in total cycle time compression (Mason-Jones and Towill, 1999a). Use of IT tools minimizes the information distortion, which improves the information flow lead-time reduction. To leverage the information and people in an agile supply chain, Meade and Sarkis (1999) and Christopher and Towill (2001a), have stressed the need of cross-function training. Investment in high technology and the MRP system help in mastering change and uncertainty, which is a key dimension of agility in a supply chain (Goldman et al., 1995). The market sensitiveness of a supply chain is affected by the level of collaboration among its trading partners, and its ability of using IT tools. Collaboration improves trust among trading partners, which motivates them to share business information and to work on the same data (Agarwal and Shankar, 2003). Trust among trading partners in inter-organisational relationships improves communication and dialogue and creates common strategic visions (Sahay, 2003). These observations lead to the formulation of the hypothesis 1

The hypothesis therefore is:

H1a: OEMs and suppliers have a similar perception towards issues of the agility of a supply chain.

In the light of the above hypothesis it is also needed to see whether sectors differ in their perception to assign weights to issues in agility of a supply chain:

H1b: There is sectoral difference in perception towards issues of the agility of a supply chain.

Table I: Independent Samples t-test for issues in agility of supply chain (OEM vs. Suppliers)

Issue	Sample		OEM (N = 105)		Supplier (N = 74)		Independent t test		
	Mean	S.D.	Mean	S.D.	Mean	S.D.	t	df	Sig.*
Lead time reduction	4.156	1.021	4.486	0.815	3.924	1.0892	3.952[b]	176.3	0.001*
Total cycle time compression	4.245	0.957	4.716	0.6521	3.9143	1.0011	6.485[b]	176.0	0.002*
Information distortion among partners	3.983	1.019	4.324	0.9082	3.7429	1.0287	3.906[a]	177	0.001*
Cross-functional training	3.312	1.102	3.310	0.9641	3.3143	1.1955	-0.021	177	0.984
Investment in high technology	3.486	1.143	3.635	0.8848	3.381	1.2889	0.564[b]	176.9	0.120
Investment in MRP system	3.519	1.123	3.6622	0.8956	3.419	1.254	1.513[b]	176.9	0.132
Trust among trading partners	4.229	0.812	4.3784	0.7531	4.1238	0.84	2.083[a]	177	0.039

Where: t^a value is with equal variance assumed and t^b value is with equal variance not assumed. Values with superscript * are significant at 0.05 level. * 2-tailed significance value

Survey Responses and the Respondents' Profile

Questionnaires have been administered to manufacturers and suppliers from three sectors. Out of the 760 questionnaires sent 179 usable responses have been received, resulting in a 23.55 per cent response rate. This response rate is considered adequate for such surveys (Malhotra and Grover 1998). Out of the 179 usable responses, original equipment manufactures (OEM) are 41 per cent while suppliers are 59 per cent (Fig. 2).

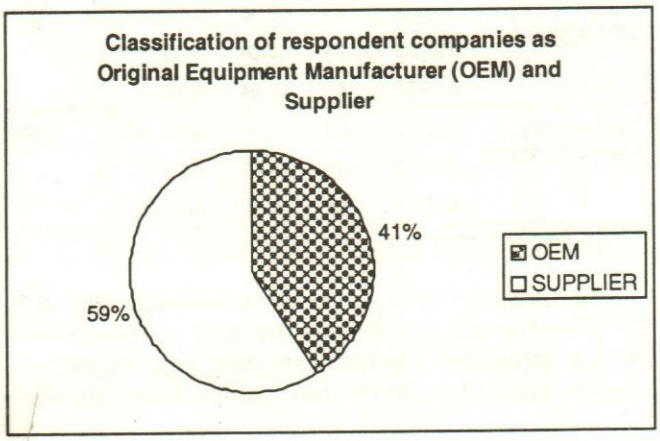


Fig. 2. Distribution of the respondent firms as original equipment manufacturers and suppliers

Sector wise distribution (Auto-46 per cent, FMCG 25 and Electrical and Electronics-29 per cent) is shown in Fig. 3.

In most cases, the addressee filled the questionnaire on their own, while in some cases other senior executives filled these questionnaires on their behalf.

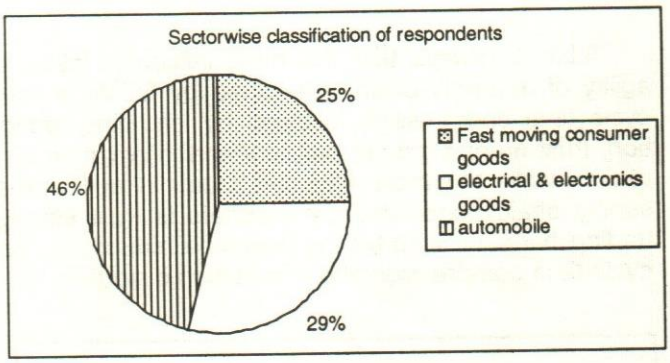


Fig. 3. Sectorwise distribution of the respondent firms

The majority of respondents held upper level positions such as President, Vice President, Chief Executive Officer (CEO), Managing Director, General Manager and Manager etc.

Testing of Hypotheses

Independent sample test and ANOVA were conducted to test the proposed hypotheses on the SPSS version 10.00 software. For quick reference each of the hypotheses is reproduced before testing its validity.

Hypothesis 1a

OEMs and suppliers have similarity in their perception towards issues of the agility of a supply chain.

To remain within the scope of this paper, the relevant portion of the questionnaire survey, which pertains to the agility, has been used in this paper.

The variation in the perception of OEMs and sup-

pliers on select issues in agility of supply chain is depicted through bar chart (Fig. 4).

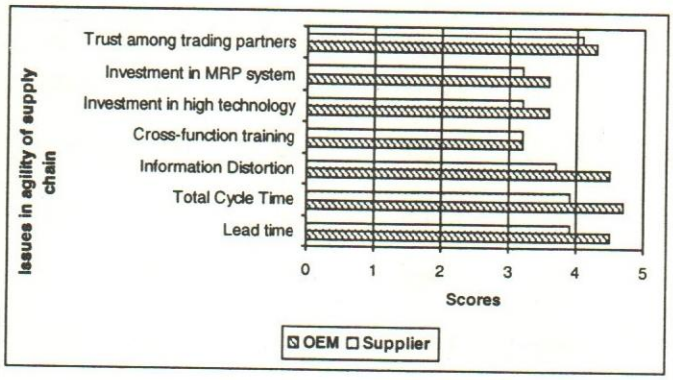


Fig. 4. Perception of OEMs and suppliers towards the influence of factors in agility of supply chain

The relevant descriptive statistics are shown in the Table I.

Table 1 reveals that the most influential issue in agility of a supply chain considered by OEMs is total cycle time compression followed by lead-time reduction, trust among trading partners and information distortion, while the most influential factor in agility of a supply chain considered by suppliers is trust among trading partners, followed by lead-time reduction, total cycle time compression and information distortion.

The most influential issue in agility of a supply chain considered by OEMs is total cycle time compression.

Independent Samples Test has been carried out on the data collected from manufacturers and suppliers. Table 1 shows the 2-tailed significance values for the various issues in agility of supply chain. A notable point is that issues like lead-time reduction, total cycle time, information distortion, and trust among trading partners have 2-tailed significance values less than 0.05. This implies that null hypothesis can be accepted at the significance level of 0.05. Therefore it can be concluded that perception of OEMs and suppliers significantly do differ on these issues. Issues like cross-functional training, investment in high technology, and investment in the MRP system have 2-tailed significance values greater than 0.05. This implies that the null hypotheses cannot be accepted at the significance level of 0.05. Therefore it can be concluded that the perception of OEMs and suppliers significantly do not differ on these issues.

Hypothesis 1b

There is sectoral difference in perception towards issues in agility of a supply chain

To test the hypotheses 1b, ANOVA test has been conducted (Table 2).

Table 2: ANOVA Test for issues in agility of a supply chain

Issues in integration of supply chain	Sectors	N	Mean	S.D.	ANOVA	
					F	Sig.*
Lead time reduction	AUTO	83	4.53	0.73	11.918	0.001*
	FMCG	45	3.91	0.79		
	ELECT	51	3.76	1.35		
Total cycle time compression	AUTO	83	4.53	0.72	10.04	0.001*
	FMCG	45	4.22	1.00		
	ELECT	51	3.80	1.10		
Information distortion among supply chain partners	AUTO	83	4.39	0.88	14.09	0.001*
	FMCG	45	3.71	0.94		
	ELECT	51	3.57	1.06		
Cross-functional training	AUTO	83	3.96	0.85	38.62	0.001*
	FMCG	45	2.82	0.78		
	ELECT	51	2.69	1.14		
Investment in high technology	AUTO	83	3.89	0.99	10.89	0.002*
	FMCG	45	3.09	1.20		
	ELECT	51	3.18	1.13		
Investment in MRP system	AUTO	83	3.86	1.03	11.76	0.001*
	FMCG	45	3.56	1.03		
	ELECT	51	2.94	1.14		
Trust among trading partners	AUTO	83	4.49	0.77	9.57	0.003*
	FMCG	45	4.09	0.67		
	ELECT	51	3.92	0.87		

* 2-tailed significance value

All the issues have significance value less than 0.05; therefore the null hypotheses that sectors do not differ in their perception towards assigning importance to issues in agility of a supply chain cannot be accepted.

Sectors do not differ in their perception towards assigning importance to issues in agility of a supply chain.

To further analyze the difference in the perception of FMCG and ELECT, AUTO and ELECT and AUTO and FMCG, the following hypotheses have been framed:

Table 3: Independent Samples Test for issues in agility of a supply chain (between sectors)

Issues affecting agility of supply chain	Independent sample test								
	FMCG vs. ELECT			AUTO vs. ELECT			AUTO vs. FMCG		
	t	df	Sig.	t	df	Sig.	t	df	Sig.*
Lead time reduction	0.657[b]	82.395	0.513	3.721	68.633	0.001*	4.414	126	0.001*
Total cycle time compression	1.946[a]	94	0.055	4.206	76.853	0.002*	1.828	69.495	0.072
Information distortion among supply chain partners	0.69[a]	94	0.492	4.602	91.209	0.001*	4.031	126	0.001*
Cross-functional training	0.689[b]	88.61	0.492	6.915	83.828	.0010*	7.488	126	0.001*
Investment in high technology	0.368[a]	94	0.713	3.856	132	0.001*	3.831	76.579	0.001*
Investment in MRP system	2.753[a]	94	0.007*	4.684	97.509	0.002*	1.574	126	0.118
Trust among trading partners	1.048[a]	94	0.298	3.976	132	0.001*	2.97	126	0.004*

Where: t^a value is with equal variance assumed and t^b value is with equal variance not assumed. Values with superscript* are significant at 0.05 level*. 2-tailed significance value.

HIc: There is similarity in the perception of FMCG and ELECT sectors towards assigning importance to issues affecting agility in a supply chain.

HId: There is similarity in the perception of AUTO and ELECT sectors towards assigning importance to issues affecting agility in a supply chain.

HIe: There is similarity in the perception of AUTO and FMCG sectors towards assigning importance to issues affecting agility in a supply chain.

To test the above hypotheses, three independent sample tests have been conducted. The results of independent sample tests have been shown in Table 3.

Results reported in Table 3 shows that null hypotheses for FMCG and ELECT sectors cannot be accepted for issues of lead time reduction, total cycle time compression, information distortion among supply chain partners, cross functional training, investment in high technology, and trust among trading partners. The null hypotheses for AUTO and ELECT sectors is accepted for all issues. Similarly null hypotheses for AUTO and FMCG sectors are accepted for all issues except total cycle time compression and investment in MRP system.

Discussion and Implications

This study empirically examines the affects of issues in agility of a supply chain. These effects have been analyzed in the Indian context. Earlier studies in the Indian context were either based on low sample size or limited to descriptive statistics (e.g., Sahay et al. 2003). The present study establishes the relative importance of issues, which influence agility in a supply chain. For example, total cycle time compression (4.245) has come out as the most important issue followed by trust among trading partners (4.229) and lead-time reduction (4.156). However, the management of a supply chain would be more interested in knowing what issues are considered influential, for improving supply chain agility. It is observed from the hypothesis 1 that out of the seven issues used in this hypothesis, cross-functional training, investment in high technology, investment in MRP system, and trust among trading partners (at 0.03 significance level) are the issues on which perceptions of original equipment manufacturers and suppliers do not differ significantly.

This study has several implications for managers too. In the sectoral analysis, total cycle time compression is the most important issue in agility of a supply chain followed by lead-time reduction and trust among trading partners. Therefore, the management should give due consideration to these issues for improving supply chain agility.

Results of the study further indicate that there is significant sectoral difference towards assigning importance to the issues in agility of a supply chain (hypothesis 1b). However, difference in the perception of fast moving consumer goods and electrical and electronics goods sectors is not significant towards lead time reduction, total cycle time compression, information distortion among supply chain partners, cross-functional training, investment in high technology, and trust among trading partners. The differences in the perception of auto and fast moving consumer goods sectors, and auto and electrical and electronics

goods sectors are significant towards lead time reduction, information distortion among supply chain partners, cross-functional training, investment in high technology, and trust among trading partners.

The management of a supply chain should further explore the various options to compress the total cycle time, reduce lead-time, and develop trust among trading partners.

Therefore, the management of a supply chain should further explore the various options to compress the total cycle time, reduce lead-time, and develop trust among trading partners. For example, in managing supply chain, some other management strategies such as total quality management (TQM) and business process reengineering (BPR) may also be explored for enabling cycle time reduction and developing trust among trading partners.

Limitations and Scope for Future Work

A significant limitation of this research is the relative homogeneity of the managers in the response sample. The managers who responded to the survey represent the top management level, with most respondents serving at high-level posts in their organisations. While a homogeneous response sample is acceptable in such exploratory studies, the lack of variety in the firms and managers in the sample may explain some of the non-significant results. For example, high-level managers may be the best source of the strategic information that is exchanged with the trading partners, but lower level managers in the field are the employees most involved in exchanging operational information. Therefore, a better indication of the operational information exchange may come from lower level managers, who were not included in the sample. Therefore, future research should include lower level managers when collecting the operations-related information. Another limitation of the study is the absence of the other issues that may be relevant in the present study. For example, the issues such as buyer-supplier relationship, waste reduction, flexible response, postponement fulfillment etc. may also be considered in the future studies. The sample size was very small and therefore the findings of the survey cannot be generalized. Only a small segment of supply chains belonging to the respondent companies were covered in the survey. Individual measures such as perceptions of the respondent company about importance of issues in agility of supply chain reflect only the opinion of the respondent firm or individual representing the firm based on his/her experience from the entire upstream and downstream supply chain. Consideration of downstream trading partners will make this study more fruitful for any outcome. The present study is only confined to limited number of issues affecting agility in a supply chain. Inclusion of more issues would make this study more useful for industries.

Conclusion

The research discussed in this paper focuses on the agility of Indian supply chains. The hypothesized findings validate some important and widely discussed aspects of supply chain agility. In the present paper, lead time reduction, total cycle time compression, information distortion among supply chain partners, cross functional training, investment in high technology, investment in MRP system, and trust among trading partners have been considered as the main issues which affect the agility of a supply chain. The research results demonstrate that agility in a supply chain can be improved by focusing on these strategies. Agility of a supply chain can build and sustain competitive advantage and ultimately lead to better business performance.

Reference

Agarwal A. and Shankar R. (2003), "On-line trust building in e-enabled supply chain", Supply Chain Management: An International Journal, Vol. 8 No. 4 pp. 324-334.

Bal J., Wilding R., and Goundry J. (1999), "Virtual teaming in the agile supply chain", International Journal of Logistics Management, Vol. 10 No. 2, pp. 71-83.

Christopher M. (2000), "The agile supply chain, competing in volatile markets", Industrial Marketing Management, Vol. 29, pp. 37-44.

Christopher M. and Towill D.R. (2001), "An integrated model for the design of agile supply chains", International Journal of Physical Distribution and Logistics, Vol. 31 No. 4, pp. 235-246.

Gandhok T., Kulkarni S. and Dewivedi, A. (2002), "India's largest business creators", Business-today, 17 February, pp. 44- 61, New Delhi.

Goldman S.L., Nagel R.N. and Preiss K. (1995), "Agile Competitors and Virtual Organisations" (New York: Van Nostrand Reinhold).

Jayaram J., Vickery S.K. and Droge C. (1999), "An empirical study of time-based competition in the North American automotive supplier industry", International Journal of Operation and Production Management, Vol. 19 No. 10, pp. 1010-1033.

Jharkharia S. and Shankar R. (2004), "Supply chain management: some insights from Indian manufacturing companies", Asian Academy of Management Journal, Vol. 9, No. 1, pp. 79-97, January.

Kim J.Q. and Mueller C.W. (1978), "Factor analysis: statistical methods and practical issues", Sage publications, London.

Lambert D.M. and Harrington T.C. (1990), "Measuring non-response bias in customer service mail surveys", Journal of Business Logistics, Vol. 11 No. 2, pp. 5-25.

Lau H.C.W., Wong C.W.Y., Pun K.F. and Chin K.S. (2003), "Virtual agent modeling of an agile supply chain infrastructure", Management Decision, Vol. 41 No. 7, pp. 625- 634.

Molhotra M.K. and Grover V. (1998), "An assessment of survey research in POM: from constructs to theory", Journal of Operations Management, Vol. 16 No. 4, pp. 407-425.

Mason-Jones R. and Towill D.R. (1999), "Total cycle time compression and the agile supply chain", International Journal of Production Economics, Vol. 62, pp. 61-73.

Naylor J.B., Naim M.M. and Berry D. (1999), "Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain", International Journal of Production Economics, Vol. 62, pp. 107-118.

Nunally J.C. (1978), "Psychometric Methods", McGraw Hill, New York.

Pati R.K., Prem Vrat and Kumar Pradeep (2003), "Reverse logistics model in the paper industry", Productivity, Vol. 44 No. 3, pp. 443-449.

Power D.J., Sohal A.S. and Rahman S. (2001), " Critical success issues in agile Supply chain Management: an empirical study", International Journal of Physical Distribution and Logistics, Vol. 31 No. 4, pp. 247-265.

Prater E. Biehl M. and Smith M.A. (2001), "International supply chain agility tradeoffs between flexibility and uncertainty", International Journal of Operations and Production Management, Vol. 21 No. 5/6, pp. 823-839.

Sahay B.S. (2003), "Supply chain collaboration: the key to value creation", Work Study, Vol. 52 No. 2, pp. 76-83.

Svensson G. (2001), "Perceived trust towards suppliers and customers in supply chains of the Swedish automotive industry", International Journal of Physical Distribution and Logistics Management, Vol 31 No. 9, pp. 647-662.

Stratton R. and Warburton R.D.H. (2003), "The strategic integration of agile and lean supply", International Journal of Production Economics, Vol. 85, pp. 183-198.

Tolone W.J. (2000), "Virtual situation rooms: connecting people across enterprises for supply chain agility", Computer Aided Design, Vol. 32, pp. 109-117.

Yusuf Y.Y., Gunasekaran A., Adeleye E.O. and Sivayoganathan K. (2003), "Agile supply chain capabilities: determinants of competitive objectives", European Journal of Operational Research, Vol. 159, pp. 379-392.

□

One of the tests of leadership is the ability to recognize a problem before it becomes an emergency.

– Arnold Glasgow

Feature

Philosophy, Principles and Productivity of Lean Manufacturing

Nesa L'abbe Wu & Curtis Walker

Lean manufacturing tools eliminate waste in the system and consequently reduce the cost of manufacturing. Lean manufacturing translates into manufacturing lead time reduction, WIP reduction, quality improvement, better space utilisation, improved customer satisfaction and ultimately increased overall productivity. It drives the cost of manufacturing down and makes companies more profitable. A simulation example illustrates the journey towards lean manufacturing via value stream mapping.

Nesa L'abbe Wu is Professor of Production Operations Management at Eastern Michigan University, U.S.A.; and Curtis Walker is a Performance Improvement Specialist at GDC Total Business Solutions.

Lean operations are the newest approach to managing operations and are based on the principles of elimination of waste, while maximizing quality and flexibility. The fundamental objective is to provide perfect value to the customer through a perfect value creation from order entry to final shipment.

The journey to "lean" started in the early 1980s with the Toyota production system (TPS) and the Toyota just in time (JIT) system. According to the president of Toyota Motors Taiichi Ohno, TPS is a total management system in which people are expected to fully utilize and facilities and machines to satisfy customer requirements while working towards absolute elimination of waste. Other elements that lead to lean thinking include total quality management (TQM); flexible manufacturing systems (FMS); optimal production technology and the theory of constraints (OPT/TOC); quality function deployment (QFD); and six-sigma.

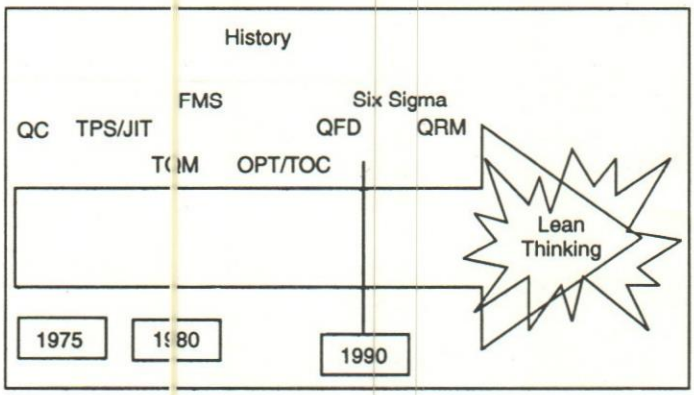


Fig. 1. Historical Perspective of Lean Development

Total quality management and six-sigma are business processes that drastically improve the bottom line of a business by designing every day's business activities in ways that result in minimizing waste and resources, while increasing quality and customer satis-

faction. Optimal production technology and the theory of constraints control the shop floor by identifying bottle-neck operations and maximizing production in the most optimal way. Quality function deployment optimises the design function methodology that ensures that all functions of the organisation work together to provide the customers with exactly what they want.

Lean Principles Eliminate Waste and Improve Productivity

Lean manufacturing is a business philosophy that starts with the voice of the customer and focuses on the elimination of waste throughout all aspects of a business. By using certain principles, waste is identified and then eliminated or reduced on an on-going basis. Lean manufacturing initiates and supports on-going improvement.

Toyota manufacturing initiated lean philosophies in their Toyota production system. The principles of the Toyota production system are the foundation of today's lean manufacturing philosophy. The essence of lean manufacturing is to compress time from the receipt of an order all the way through to the receipt of payment for such an order. The results of this time compression are greater productivity, shorter delivery times, lower cost, improved quality, and increased customer satisfaction.

Lean manufacturing is a management system; is a way of thinking; is a culture where all employees are continuously looking for ways to improve processes. It is a philosophy of eliminating all non-value-added activities in manufacturing and non-manufacturing environments.

Lean manufacturing is a management system; is a way of thinking; is a culture where all employees are continuously looking for ways to improve processes.

The principles used to support lean manufacturing can be used by anyone. The size of a company or the types of products produced or services rendered do not make a difference to the application of these principles. There are no prerequisites for implementing lean principles. A company's dedication and willingness to learn and implement the principles are all that is required. Imperative to the success of implementing lean manufacturing is the support of top management. With this the company can begin with eliminating the waste in the system. Workers also need to receive training in lean manufacturing and learn to work in teams.

Whether one makes a product, renders a service or quotes a job, one must take action in order to accomplish the goal or task. These actions can be a combination of value added or non-value added activities. A value-added activity is an activity that increases the market, form, or function of the product or service. In other words, these are activites the customer is willing to pay for. A non-value added activity is any activity that does not add market, form, or function or is not necessary. These are the activities that the customer is not willing to pay for. These activities must therefore be eliminated, simplified, reduced or integrated.

Lean manufacturing breaks waste into eight non-value-added activities. These non-value-added activities are: overproduction, inventory waste, defects, processing waste, waiting waste, people waste, motion waste, and waste of transportation.

- *Over-production* is defined as making more than is required by the next process; making parts earlier than is required by the next process; or making parts faster than is required by the next process.
- *Inventory waste* is defined as any supply in excess of a one-piece flow through the process.
- *Defects* are defined as inspection and repair of material in inventory.
- *Processing waste* is defined as efforts that add no value to the product or service from the customers' viewpoint.
- *Waiting waste* is defined as idle time created when waiting for something to be completed.
- *People waste* is defined as the waste of not using people's mental, creative, and physical skill abilities.
- *Motion waste* is defined as any movement of people or machines that does not add value to the product or service. Waste of transportation is defined as transporting parts and materials around the plant.

Eliminating these wastes will improve labour productivity, material productivity, capital productivity and energy productivity.

The lean production/operations model of a firm

reflects lean principles for product development; principles of a lean workplace that is organized, properly laid out with standardised procedures; and principles of lean shop floor control.

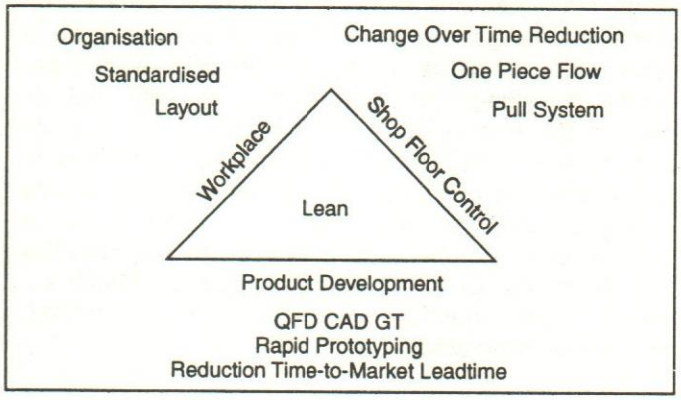


Fig. 2. The Lean Production/Operations Model

Lean Product Development

Lean product development aims at reducing waste during the development process of a product or service. Waste of the product development activity occurs when time is wasted because of poor development procedures; when customers' desires are poorly understood resulting in products that require major redesigns over their product life cycle or when products are either over or under designed. Quality function deployment aims at making the product development function more lean and more in tune with the customers' desires. It is a methodology that ensures that all functions of the organisation work together to provide the customers with exactly what they want.

Lean product development also aims at companies quickly responding to the changing needs and tastes of the customers. Successful companies increase value when they reduce or make more reliable time-to-market lead time, which is the total time that a firm takes to conceive, design, test or redesign products for the market. This requires the use of tools that accelerate product development capabilities. As mentioned in this chapter these tools are computer-aided design; computer-aided analysis and simulation; product data management software and data bases using group technology; and rapid prototyping.

Companies that have significantly decreased their time-to-market lead time are: Honda (cars from 5 years to 2 years), Navistar (trucks from 5 years to 2 years), AT&T (phones from 2 years to 1 year) and Hewlett Packard (printers from 4.5 years to less than 2 years).

Lean Work Place

Frank Gilbreth developed a list of 17 elemental motions. The purpose of this list of motions was to study work and improve it. Frank felt that by eliminating unnecessary motions and training workers to perform only necessary motions, a job can be standardised. From a lean manufacturing standpoint only very few of these 17 motions add value. Table 1 lists Gilbreth's value added and non-value added motions.

Initially, when work standards were set and used, workers were encouraged to beat the standards and were rewarded for producing more work than what the standard asked for. Special pay scales were developed to encourage workers to produce more. This individual operator efficiency that focuses on maximizing the output of each individual operator without regard for the effect on the total system is not advocated by lean manufacturing principles.

Table 1: Value of Motions

Non-Value Added Motions	Value Added Motions
Avoidable Delay (AD)	Assemble (A)
Unavoidable Delay (UD)	Disassemble (DA)
Grasp (G)	Use (U)
Hold (H)	
Inspect (I)	
Plan (PL or PN)	
Position (P)	
Pre-position (PP)	
Release Load (RL)	
Rest to Overcome Fatigue (R)	
Search (SH)	
Select (SE or ST)	
Transport Empty (TE)	
Transport Loaded (TL)	

Setting work standards and developing lean standard work methods are necessary to balance the workload for each operation to the actual demand rate. This will eliminate overproduction, excess inventory and optimize the total system's performance.

Whether it is an office or a manufacturing floor, a work place needs to be organized. A work area should be laid out properly and standardised work procedures followed so that all employees can perform their jobs in the most efficient manner. If not, some type of non-value added activity could be identified. Hence, all employees

ought to perform their jobs using the three principles of a lean work place: a workplace that is organized, that is properly laid out, and that has standardised work procedures.

Work Place Organisation

Work place organisation is defined as a safe, clean, neat arrangement of the work place. One must provide for a specific location for everything that is needed and we must eliminate anything that is not required to do the job. The principles used for the organisation of the work place are the "5S's". These consist of:

- Sort
- Straighten
- Scrub/Shine
- Spread
- Standardise

Sort what is needed and what is not needed. What is not needed must be eliminated. When you are in doubt, throw it out. Straighten what must be kept. Make what is kept visible and self-explanatory, so everyone knows where it goes. Scrub/shine everything that remains; clean the equipment, tools and the work place. Spread this clean routine to all areas of the facility and make it more automatic. This leads to standardisation. Standardisation requires discipline, adhering to the rules and making the rules a habit.

Standardised Work

The work place principle of standardised work requires that operations be safely carried out with all tasks organized in the best-known sequence and by using the most efficient and effective combination of resources. Resources include, but are not limited to people, materials, methods and machines. In other words, the way all operators are performing their tasks must be standardised. This implies that the best way to perform a task must be determined. In determining the best way, one must focus on eliminating non-value-added tasks, such as motion, waiting and repetition. Once this best method is determined all operators involved in performing the tasks must be trained. This leads to standardised work. The tools required for standardised work are:

- Time observation sheets
- Flow diagram
- Standard work sheets
- Standard work layout or work instruction.

Lean Layout

The goal of a lean layout is to allow for the production of quality parts or services at takt time (the amount of time available to produce one unit based on the customer demand rate), while minimizing non-value-added activities. A lean layout must accomplish the following:

- Facilitate the flow of material and work;
- Minimize walking;
- Minimize travel;
- Allow for the immediate flow of information and feedback;
- Promote a good balance among workers; and
- Allow for changes in the demand.

If a company's layout (whether functional line, cellular or a combination of these) does not exhibit all of these characteristics, then a change is needed. For a process or activities to flow correctly all these criteria must be met. Operations ought to be located as closely together as possible. This is where the concept of cellular manufacturing or operations comes into play. Placing progressive operations in a U-shaped cell that flows counter clockwise is one of the best options.

The cell concept promotes:

- Sharing of work;
- Balancing work amongst operators;
- Communication within the cell;
- Flexibility in managing the cell according to set rules; and
- Introduction of a pull system, rather than a push system.

If it is not possible to cellularize the entire process, then various cells can be linked with supermarkets. A supermarket is similar to a warehouse, where the stored product is policed by a kanban system. Only when the operation downstream pulls the product, depleting the inventory to the re-order point, does the operation upstream begin producing the required amount. This is communicated between the two operations via kanban triggers.

Lean Shop Floor

Lean stresses that materials be pulled through an

organisation or work place, not pushed. Push systems are the traditional systems where resources are provided to the customer based on forecasts or schedules. When materials are pulled through the system, the flow of materials is controlled by replacing only what has been consumed.

Any pull system needs a demand rate. This demand rate is called takt time:

TAKT TIME = WORK TIME AVAILABLE/ CUSTOMER DEMAND

For example, if the company has a 8-hour shift operation which allows for two ten-minute breaks, then there are 460 minutes available work time. If the actual demand from the customer is 3,000 units a day (these are actual units sold), then the takt time is:

TAKT TIME = 460 MINUTES/3,000 UNITS = 0.15 MINUTES PER UNIT

This takt time now becomes the drumbeat of the facility. In other words, a unit must be made every 0.15 minutes.

The ultimate pull system is a one-piece flow. This is a system where products are made in a batch size of one, or one unit at a time is pulled through the operation from one process to the other. A one-piece flow operation eliminates non-added value activities such as obsolescence, repair, rework, excess inventory, expediting and other wastes.

While it may not be feasible to utilize a one-piece flow operation, the closer you get to this goal, the better off the company is.

An example of the gains that can be achieved by reducing the batch size to a one piece flow is illustrated below.

Assume that the cycle time per process step is 2 minutes and one currently runs everything in batches of five. There are three processes each batch of five goes through.

It will take ten minutes before the total batch of five items will be finished in the first processing centre. It then will move on to the next processing centre. Again another ten minutes of processing occurs in the second processing centre and a final ten minutes in the third processing centre. This adds up to a total processing time of 30 minutes. The first part leaves the system when it has been processed in the third processing centre, or after 22 minutes in the system (10 minutes in process one + 10 minutes in process two + its processing time of 2 minutes in process three).

If we go to a one-piece flow (continuous flow) type of a system, then the first piece moves to processing centre two as soon as it is processed in centre one, and moves ot the third centre as soon as it processed in centre two. This yields a reduction in total lead time from 30 minutes to 14 minutes and in a lead time reduction for the first piece from 22 minutes to 6 minutes (its actual production time).

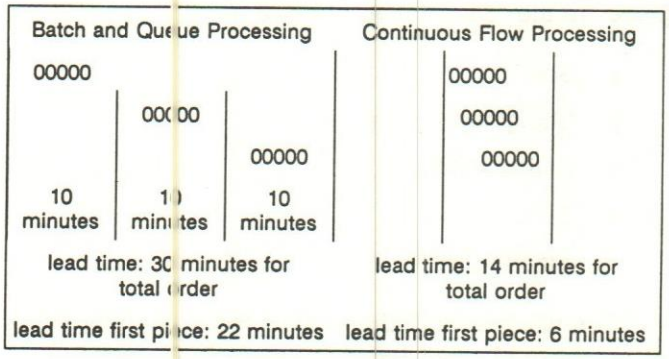


Fig. 3 Batch versus continuous Flow System

In order to facilitate many of the already mentioned principles of lean manufacturing and operations, changeover time must be reduced. Changeover time is defined as the time between the last piece coming off the current run and the first good piece coming off the next run. In other words, machine changeover is the action required for preparing a machine or process for work different than currently or previously performed. It is commonly known as machine set-up.

A typical changeover time reduction project normally involves two phases.

The first phase involves the systematic study of the present setup procedure to examine and identity existing waste. It involves the following steps:

1. Management establishes a target/goal. Without a clear directive from management, any such project is sure to fail. It is therefore essential that management provides the target.
2. Create a project team that has cross-functional capabilities amongst its membership. It is often helpful to establish teams consisting of an operator, a set-up person, a toolmaker, a planner/scheduler, and a design engineer and project leader.
3. Prepare a project specific training programme

and train team members in team building skills, problem solving, small group improvement activities, and set-up reduction methods.

4. Assign team members to specific data gathering tasks. Because of the variety of different tasks that must be addressed, establishing clear team objectives help the team stay focused.
5. Videotape and document a first set-up.
6. Perform a video analysis.
7. Review and sort team ideas on set-up elements into internal/external/parallel series. One of the major tasks of the changeover time reduction team is to identify activities within the set-up process that can be transferred from an internal activity to an external activity. Internal activities are defined as steps during which the machine must be shut down or is in set-up mode. External activities include all actions that occur while the machine is in production mode. Therefore, set-up time reduction projects focus on processes that can be moved from an internal activity to an external activity. This results in increasing production capacity and providing shorter changeover times.
8. Develop action plans required to meet team objectives and assign areas of responsibility.
9. Develop a revised/new set-up procedure. It is often found that the process of a machine set-up is not defined and that a changeover time reduction team prepares a standard procedure for changeover on a machine for the first time.
10. Videotape the second revised and improved set-up procedure, review it and implement new changes. This is the test and fine-tuning of revised changeover procedures. Often teams realize that specific issues need to be redefined in the procedure to get a maximum return.
11. Write and publish the revised set-up procedure. This document becomes the master for the machine/process. By using this master the changeover is standardised and training and repetition will soon provide set-up efficiency.
12. Document and present results of the programme to management. In order to assure that the team has accomplished its goals, management must acknowledge the results and formally close this initial phase of the project.

The second phase of set-up time reduction focuses on major equipment and tooling issues in order to further reduce the set-up time.

By using set-up reduction techniques, companies will achieve the following benefits:

- Lower set-up times
- Ability to do more frequent set ups, thus gaining production flexibility
- Ability to run smaller batches
- Shorter lead times
- Less work in process
- Implementation of just in time manufacturing and one piece flow
- Cellular manufacturing
- Extra floor space

Value Stream Mapping: Starting the Journey Towards Lean Manufacturing

Value stream mapping is a process utilized to steer from a current inefficient process to a future lean process environment. The process of value stream mapping begins by documenting the flows of the existing process in a "current state" map. Analysing the current state map and applying lean manufacturing principles result in the "future state" map.

A value stream map is a visual representation of the production/operations path, documenting flow of materials and information. It is drawn by following a product's production path from beginning to end, and drawing a visual representation of every process in the material and information flows. The map is normally drawn by hand, by following a product from the ordering and delivery of raw materials, components and assemblies, through to shipping and delivery to the customer. The map includes both material and information flows.

Material flow data list:

- Order quantities and order lead time,
- Modes of shipment of materials (including transportation frequencies),
- Receiving and storage points (including the warehouse for received materials, work-in-process, and finished goods inventory),
- Production processes,
- Production lead times: the length of time between the release of an order to the shop floor and the shipment to the final customer or receipt into finished stores,

- Value added time: the actual productive time of processes contributing values towards the final product,
- Flow of work-in-process (WIP) between production processes, and
- Mode of shipment of finished product to the customer (including transportation frequencies and time), major customers, distribution centres or warehouses.

Information flows reflect:

- Electronic or manual information control systems,
- Material requirement planning (MRP) or manufacturing resource planning (MRPII) systems, and
- Enterprise resource planning (ERP) and supply chain management (SCM) systems.

To illustrate the process of using value stream mapping to improve operations and flows consider the following example that is based on a simulation developed by one of the authors and used in various seminars on lean manufacturing.

The current state map of the example is shown in Figure 4.

The value stream map of Figure 4 illustrates a production of "Black Rangers" and "Red Rovers". Seven production stations and a quality control station make up the production system. An MRP system is used to generate the daily schedules. Parts are shipped by truck from a warehouse and finished goods are shipped by truck directly after production to the customers. Because the total value added time is 23 seconds and the customer takt time is 20 seconds (customers require three units per minute) this system cannot meet the customer's demand. The total production lead time of all work in process (WIP) is 518 seconds, while the actual value added time is 23 seconds.

Lean manufacturing principles attempt to eliminate waste in the system. Waste occurs when there is overproduction, excessive inventory, defects, excessive material handling and transportation, unnecessary motions, waiting or extra processing. Producing what the

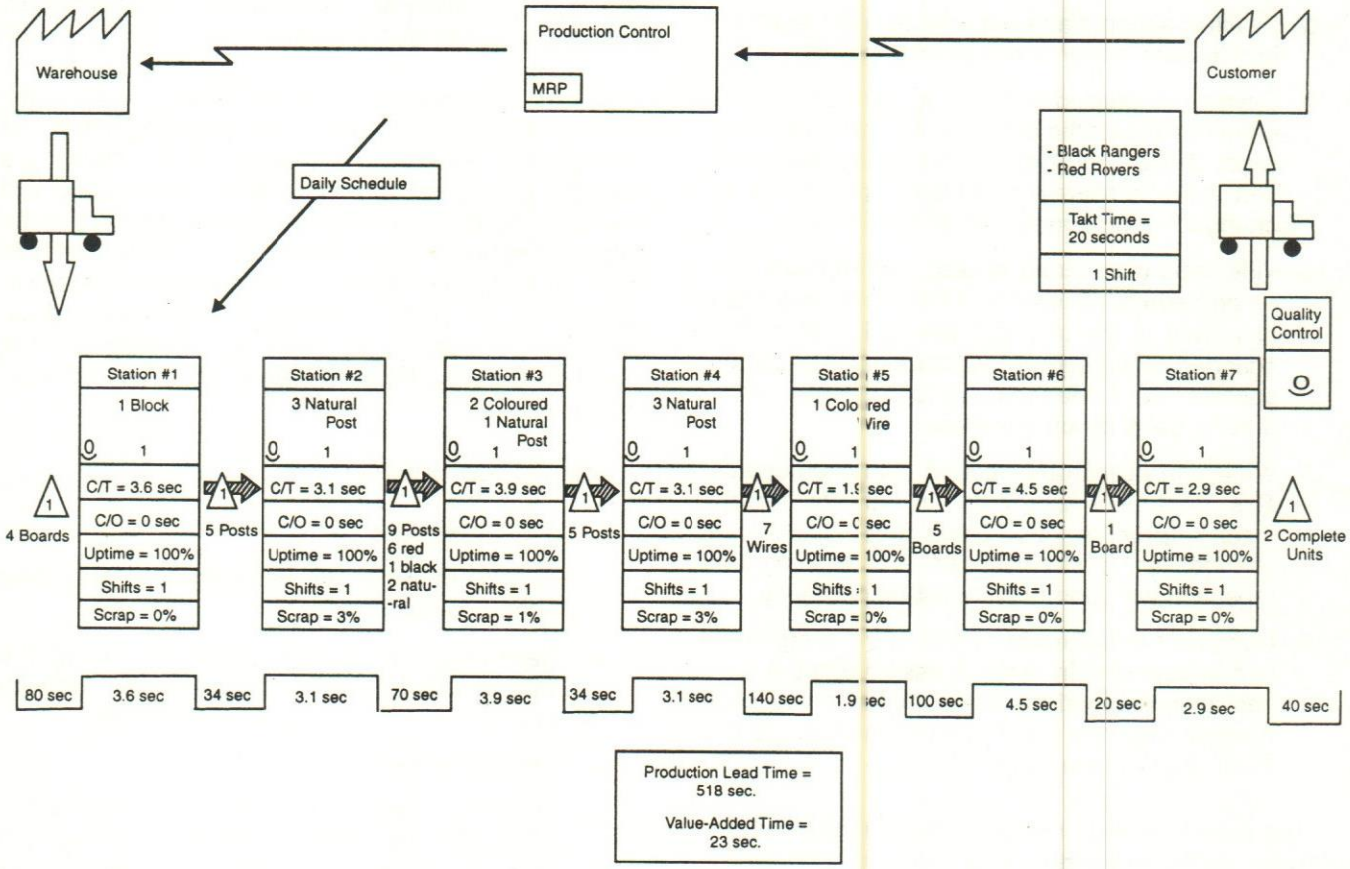


Fig. 4. The Current State Map

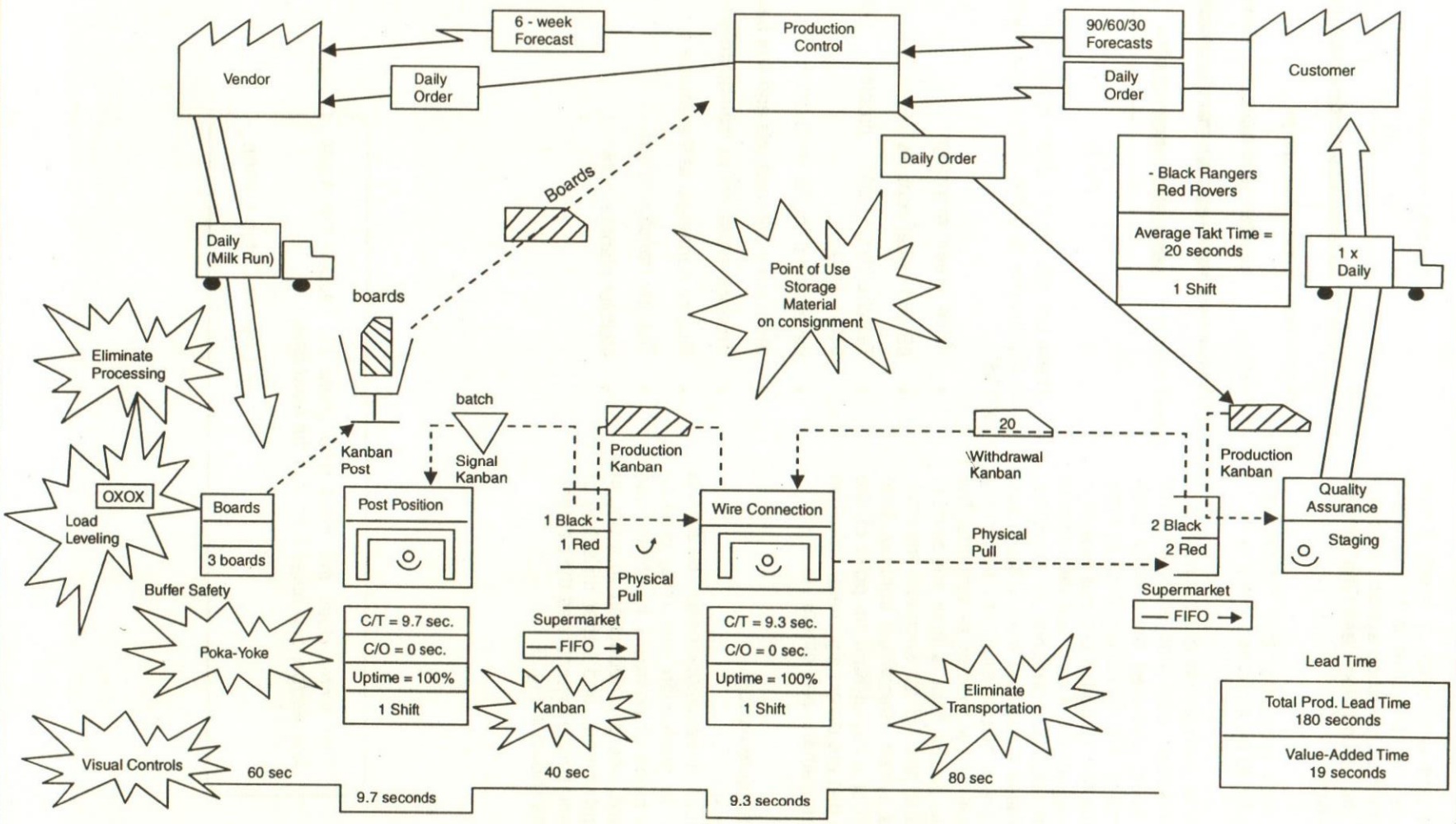


Fig. 5. Future State Map

next process needs and only when it needs it can eliminate these waste. The objective is to move the product faster through the production system, thus significantly reducing the production lead-time or the manufacturing cycle time.

When applying lean principles, the "future state map" for this factory could be as shown in Fig. 5.

Figure 5 shows a re-arrangement of stations, reducing unnecessary work-in-process and activities. The materials are now being delivered on a daily basis directly from the vendors. A buffer/safety stock of three boards is stored at the first station. It is a pull system in which work centres signal with a card that they wish to withdraw parts from feeding operations or suppliers. The production lead-time is reduced from 518 seconds to 180 seconds. There is also a slim reduction in the value added time from 23 seconds to 19 seconds. The 19 seconds of value added time is now sufficient to meet a customer takt time of 20 seconds. Improvements made to this system are: visual controls, load leveling, introduction of a signal Kanban, point of use storage of materials that are on consignment, reduction in transportation or movement, and others.

Benefits of Lean Implementation

The benefits of lean implementations can be seen in significant reduction in production lead time, productivity increase in all areas of company inputs (labour, materials, capital and energy), reduction in work in process, quality improvement, and better utilisation of space. Some companies have experienced the percentage improvements as shown in Fig. 6.

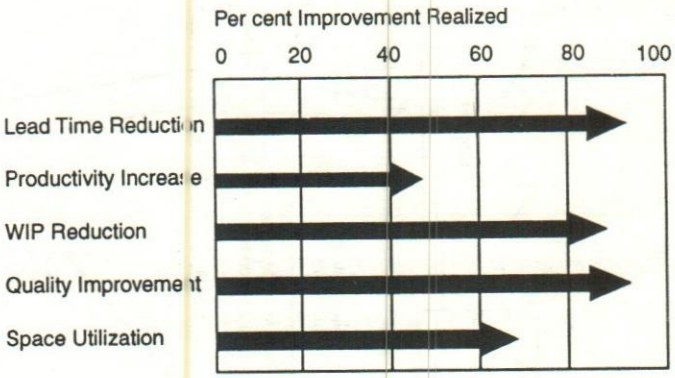


Fig. 6.

These benefits are the direct result of the implementation of principles and practices of lean manufacturing, such as:

- Value stream mapping
- 5S and visual controls
- Team building and problem solving Pull scheduling
- Level mixed model production
- Standard work methods and line balancing
- Productive/preventive maintenance
- Quality controlled at the source
- Cultural transformation
- Cellular plant layouts

□

That writer does the most who gives his reader the most knowledge, and takes from him the least time.

– Charles Caleb Colton

Feature

Causal Relationships for Supply Chain Management in the Indian Automobile Sector

S. Balan, Prem Vrat & Pradeep Kumar

The Indian automobile industry's supply chain is affected by many factors and there is a wide gap between its Present Supply Chain Management Index (PSCMI) and the Ideal Supply Chain Management Index (ISCMI). To reduce the gap and to improve the present SCMI, the dynamic interactions among the factors affecting SCMI have been analysed in this paper by developing a causal relationship between them. The resulting Causal Loop Diagram (CLD) provides an insight into understanding the dynamic interactions among the identified supply chain variables and helps the automobile manufacturers to improve their present supply chain architecture.

S Balan is a research scholar, Prem Vrat is director and Pradeep Kumar is Professor at IIT Roorkee.

There has been a remarkable transformation of the car industry in India from the 1990's. At the beginning of the decade there had been only a very limited involvement of multinational firms, and total production volumes remained modest. The scenario changed in 1991 when India produced about 209,000 cars and foreign involvement was achieved by means of a link up with Suzuki. The Suzuki-Maruti company (now Maruti Udyog) was formed and this soon become successful (John Sutton, 2004).

From the early '90s onwards, a number of multinational firms entered into India's markets. These entrants were required to achieve a high level of domestic content within a specified period (typically, 70% within 3 years). For at least some of the new entrants, this was seen as an unreasonable target as domestic suppliers could not meet the price and quality requirements of the car makers. Achieving the 70% target required the car makers to switch rapidly from a reliance on imported components to sourcing from local vendors; and this in turn gave the car makers a strong motivation to work closely with (first-tier) suppliers, to ensure that quality standards were met within an acceptable price. Table 1 shows the leading car manufacturers in India; the number of unit's production per year and their market share.

Most of the automobile companies operating in India keep their assembly and distribution centre here while having the main research and development, design and manufacturing centre in their home countries. One of the major reasons for the dry performance of the Indian automobile industry in the world market is the lack in the supply chain structure, a concept which is nascent in India (Prem Vrat, 1998). Increasing uncertainty of supply networks, globalisation of businesses, proliferation of product variety and shortening of product life cycles have forced Indian organiza-

tions to look beyond their four walls for collaboration with their supply chain partners.

Table 1: Leading Car Makers in India, 2001-2002

	Types of Makers	No. of units produced	Market Share
1	Maruti Udyog Ltd (Suzuki j.v.)	351,949	62.2%
2	Hyundai Motor India Ltd.	93,888	16.5%
3	Tata Engineering and Locomotive Co. Ltd.	64712	11.5%
4	Hindustan Motors Ltd.	19398	3.4%
5	Ford India Ltd.	14306	2.5%
6	Hero Honda Motors Ltd.	10310	1.8%
7	General Motors India Ltd.	8135	1.4%
8	Daimler Chrysler India Pvt. Ltd.	1415	0.2%
	Total Production (All firms*) Share of top eight	564,113	100%

*A small number produced by Fiat and by Daewoo is not available.

Source: ACMA, Facts and Figures: Automotive Industry India, 2001-2002

Literature review

Many articles discuss the system dynamics model and its application related to a simple supply chain. Toru Higuchi and Marvin D.Troutt (2004) discussed scenario-based dynamic simulations to study the short product life cycle case exemplified by a "Tamagotchi" case. Lai, Lee and Ip (2003) developed a system dynamics model for the just-in-time (JIT) environment. Their integrated framework of JIT and Kanban model provides a new paradigm to analyze the logistics policies of a company and understand the customers, competitors and suppliers interaction that shape the company's performance over time. Shotaro Minegishi and Deniel Thiel (2000) developed a system dynamics model that could contribute to improving the knowledge of the complex logistics behaviour of an integrated food chain. Oscar Rubiano Ovalle and Adolfo Crespo Marquez (2003) presented a classification of managerial spaces where multiple trading partners share critical information using e-collaboration tools and assess the possible local and global impact on the supply chain performance. Adolfo Crespo Marquez and Carol Blanchar (2004) carried out a simulation study to extend current methods for real options strategies in the management of strategy commodity-type parts. Satsangi et al., (2003) developed a system dynamic model to analyze dynamics of system behaviour in terms of various performance indicators representing city problems. Khanna et al., (2003) used the system dynamics model to identify various dynamic interactions among the subsystems of Total Quality Management. Bernhard and Marios, (2000) developed a system dynamic model in supply chain management focusing on the Forrester's supply chain.

Almost in all the cases the researchers describe SCM as a system but the dynamics interactions among its subsystems and the factors influencing SCM have not been paid due attention in the literature. The System Dynamics methodology can be widely used for supply chain modeling, its policy issues and its operational problems. Application of system dynamics in developing a SCM Index has got great important. A SCM Index is an aggregate score for SCM implementation strategies and its variables. Figure 1 shows the way in which one can achieve an ideal state of SCMI from its present state.

Table 2: Definition of main supply chain variables

Variables	Remarks
Present SCMI (PSCMI)	Current Supply Chain Management Index of an organization.
Ideal SCMI (ISCMI)	Target Supply Chain Management Index of an organization.

Identification of SCM variables

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, 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%). The collected feedback reply of the questionnaire was analysed. From the analysis the various supply chain variables of opportunities, challenges and factors influencing the SCM have been chosen for this analysis. Table 2 shows the definition of main SC variables that are considered for this analysis.

Identification of SCM variables: Supply Chain (SC) Opportunities

Within the context of Indian industrial and economical development the six SC opportunities have been identified as follows:-

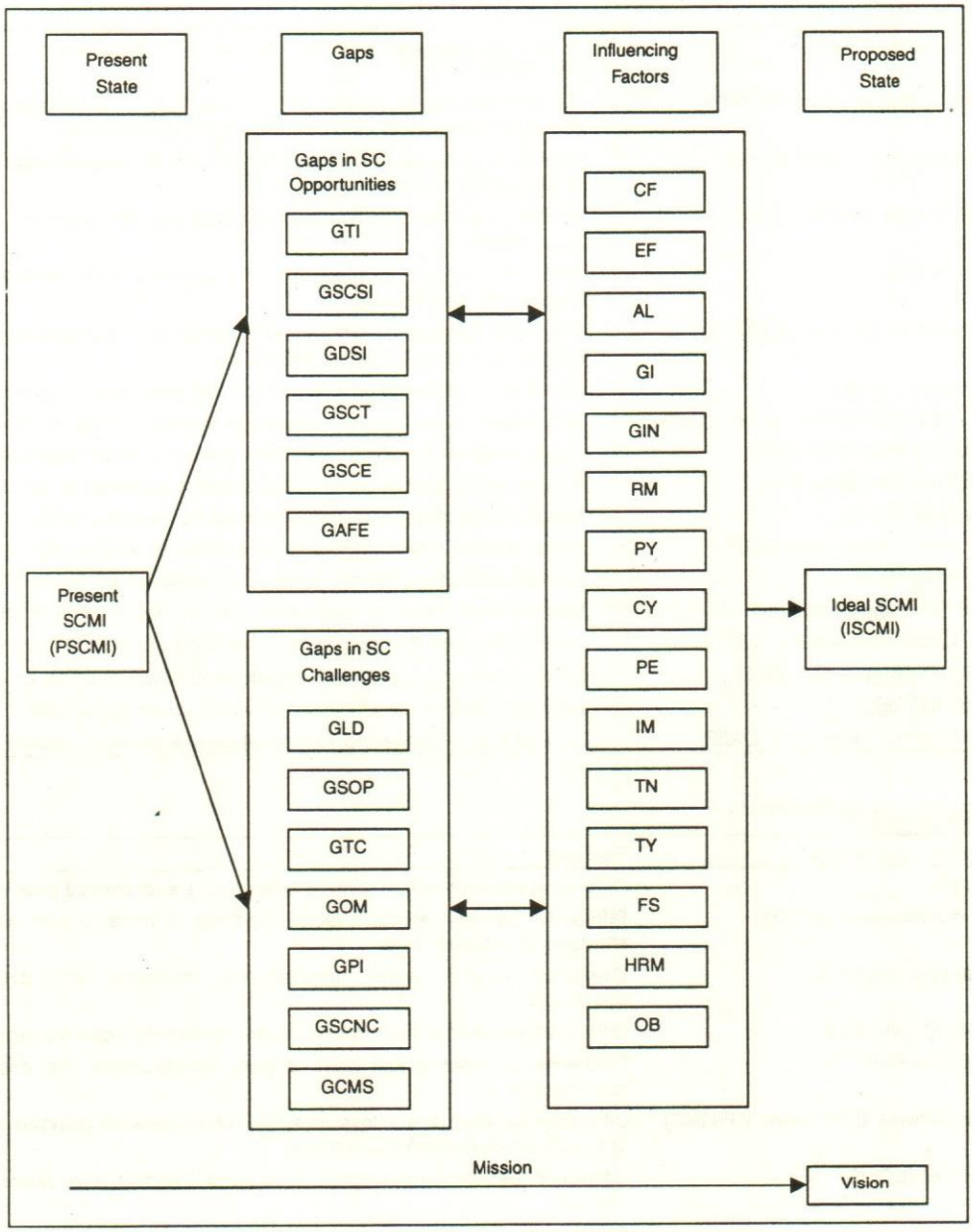


Fig. 1. Graphical representation of achieving an ideal SCMI

1. Technology Integration (TI)
2. Supply Chain Strategies Implementation (SCSI)
3. Demand & Supply Integration (DSI)
4. Supply Chain Transformation (SCT)
5. SC Efficiency (SCE)
6. Achieving Functional Excellence (AFE)

The basic supply chain opportunities variables, its derived variables and its remarks are shown in Table.3.

Identification of SCM variables: SC Challenges

Within the context of Indian socio-cultural values the seven SC challenges have been identified as follows:-

1. Limited Data (LD)
2. Shortage of Professionals (SOP)
3. Technological Challenges (TC)
4. Organizational Models (OM)

Table 3: Definition of variables for opportunities

Supply Chain Variables-Opportunities	Remarks
Gap in Technology Integration (GTI)	Difference between desired technology integration and actual technology integration.
Gap in Supply Chain Strategies Implementation (GSCSI)	Difference between desired level of supply chain strategies implementation and actual level of supply chain strategies implementation.
Gap in Demand & Supply Integration (GDSI)	Difference between desired level of demand & supply integration and actual level of demand & supply integration.
Gap in Supply Chain Transformation (GSCT)	Difference between desired supply chain transformation and actual supply chain transformation.
Gap in SC Efficiency (GSCE)	Difference between desired level of organizing SC efficiency and actual level of organizing SC efficiency.
Gap in Achieving Functional Excellence (GAFE)	Difference between desired level of achieving functional excellence and actual level of achieving functional excellence.
Actual Technology Integration (ATI)	Actual level of technology integration achieved by an organization
Actual Supply Chain Strategies Implementation (ASCSI)	Actual level of supply chain strategies implementation of an organization
Actual Demand & Supply Integration (ADSI)	Actual demand & supply integration achieved by an organization
Actual Supply Chain Transformation (ASCT)	Actual level of supply chain transformation achieved by an organization.
Actual SC Efficiency (ASCE)	Actual supply chain efficiency achieved by an organization.
Actual Achieving Functional Excellence (AAFE)	Actual level of achieving functional excellence of an organization.
Desired Technology Integration (DTI)	Desired level of technology integration achieved by an organization
Desired Supply Chain Strategies Implementation (DSCSI)	Desired level of supply chain strategies implementation of an organization
Desired Demand & Supply Integration (DDSI)	Desired demand & supply integration achieved by an organization
Desired Supply Chain Transformation (DSCT)	Desired level of supply chain transformation achieved by an organization.
Desired SC Efficiency (DSCE)	Desired supply chain efficiency achieved by an organization.
Desired Achieving Functional Excellence (DAFE)	Desired level of achieving functional excellence of an organization.

Table 4: Definition of variables for challenges

Supply Chain Variables - Challenges	Remarks
Gap in Limited Data (GLD)	Difference between actual level of limited data and desired level of limited data.
Gap in Shortage of Professionals (GSOP)	Difference between actual level of shortage of professionals and desired level of shortage of professionals.
Gap in Technological Challenges (GTC)	Difference between actual technological challenges and desired technological challenges.
Gap in Organizational Models (GOM)	Difference between actual organizational models and desired organizational models.
Gap in Poor Infrastructure (GPI)	Difference between actual level of poor infrastructure and desired level of poor infrastructure.
Gap in Supply Chain Network Complexity (GSCNC)	Difference between actual level of supply chain network complexity and desired level of supply chain network complexity
Gap in Cultural Mind Set (GCMS)	Difference between actual level of cultural mindset and desired level of cultural mindset.
Actual Limited Data (ALD)	Actual level of limited data experienced by an organization
Actual Shortage Of Professionals (ASOP)	Actual level of shortage of professionals of an organization
Actual Technological Challenges (ATC)	Actual technological challenges faced by an organization
Actual Organizational Models (AOM)	Actual organizational models employed by an organization.
Actual Poor Infrastructure (API)	Actual level of poor infrastructure of an organization.
Actual Supply Chain Network Complexity (ASCNC)	Actual level of supply chain network complexity of an organization.
Actual Cultural Mind Set (ACMS)	Actual cultural mind set of people participating in an organizations function.
Desired Limited Data (ALD)	Desired level of limited data experienced by an organization
Desired Shortage of Professionals (ASOP)	Desired level of shortage of professionals of an organization
Desired Technological Challenges (ATC)	Desired technological challenges faced by an organization
Desired Organizational Models (AOM)	Desired organizational models employed by an organization.
Desired Poor Infrastructure (API)	Desired level of poor infrastructure of an organization.
Desired Supply Chain Network Complexity (ASCNC)	Desired level of supply chain network complexity of an organization.
Desired Cultural Mind Set (ACMS)	Desired cultural mind set of people participating in an organizations function.

Table 5: Definition of variables for factors influencing SCMI

Supply Chain Variables-Influencing Factors	References	Remarks
Cultural Factors (CF)	(Klassen and Whybark, 1989)	Differences in languages and definitions.
Endowment Factors (EF)	(Porter,1986 & Kogut, 1985)	Proximity to market
Arbitrage and Leverage (AL)	(Seto, 1988)	The movements of material and location of activities to minimize the cost.
Government Incentives (GI)	(Moffat, 1992)	Government can provide an array of incentives to attract MNC's in their location.
Geographical Isolation (GIN)	(Chuda Basnet et al,2003)	Geographical Isolation greatly affects its local manufacturer with MNC's.
Raw Materials (RM)	(Chikan and Whybark, 1990)	Looking out the availability of raw materials and their relative scarcity.
Perishability (PY)	(Picard, 1982)	Monitoring the life expectancy, expected transportation time and harvest rate.
Complexity (CY)	(Vargas and Johnson, 1993)	Organizations network complexity should be reduced.
Processes Employed (PE)	(Schmenner, 1991)	Characteristics of the processes employed.
International Market (IM)	(Kogut, 1985)	Industry should avail the facility of International Market.
Transportation (TN)	(Bass et al, 1977)	It is necessary that the international supply chain must be appropriate.
Technology (TY)	(Sum and Yung, 1993)	Organization should adopt advance technology to compete with MNC's.
Financial Strategies (FS)	(Doz, 1984)	A typical supply chain can provide a financial hedge in case of turbulent international conditions.
Human Resource Management (HRM)	(Portar, 1986)	Company needs to evaluate the human resources on a global scale.
Organizational Behaviour (OB)	(Cohen and Lee, 1988)	The organizational setup needs to conform to the rationalization pattern of systems.

5. Poor Infrastructure (PI)
6. Supply Chain Network Complexity (SCNC)
7. Cultural Mind Set (CMS)

The basic supply chain challenges variables; its derived variables and its remarks are shown in Table. 4.

Identification of SCM variables: Influencing factors

The various factors affecting SCMI are listed below and are taken as System Dynamics (SD) variables to analyse its dynamics behaviour. (Refer Table.5)

1. Cultural Factors (CF)
2. Endowment Factors (EF)
3. Arbitrage and Leverage (AL)
4. Government Incentives (GI)
5. Geographical Isolation (GIN)
6. Raw Materials (RM)
7. Perish ability (PY)
8. Complexity (CY)
9. Processes Employed (PE)
10. International Market (IM)
11. Transportation (TN)
12. Technology (TY)
13. Financial Strategies (FS)
14. Human Resource Management (HRM)
15. Organisational Behaviour (OB)

Developing a Causal Loop Diagram (CLD)

System Dynamics focuses on the structure and behaviour of systems composed of interacting feedback loops. A CLD is a system dynamics tool, which encourages the modeler to conceptualise the real world systems in term of feedback loops. In a CLD the arrow indicates the direction of influence, the sign (plus or minus) indicates the type of influence. If a change in one variable generates a change in the direction in the second variable relative to its prior value, then the relationship between the two variables is positive. If a change in one variable produces a change in the opposite direction in the second variable then the relationship is negative (Goodman, 1974 and Forrester, 1961). The loop polarity can be determined by adding up the number of negative signs around the path. If the numbers of negative signs are

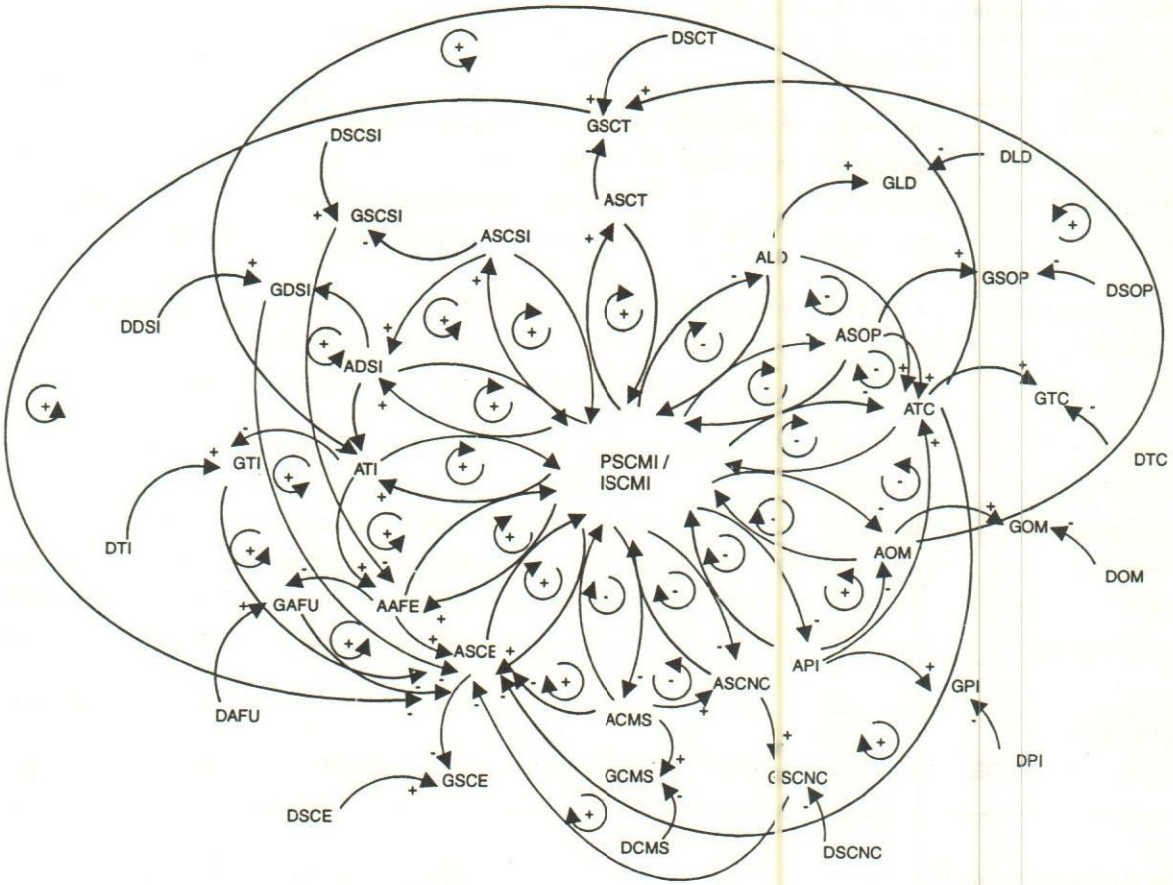


Fig. 2. Causal loop diagram for SCMI

even then the loop is positive otherwise the loop is considered as negative.

Assumptions in developing the CLD

The following assumptions have been made while developing the CLD for the SCMI. These assumptions are pertaining to the automobile manufacturers, sub-contractors and their suppliers.

- Organizations must be aware of the importance of SCM implementation philosophy
- Organizations should be aware that reducing the gap of supply chain opportunities (difference between desired supply chain opportunities and actual supply chain opportunities) and the gap of supply chain challenges (difference between actual supply chain challenges and desired supply chain challenges) would lead to increase in SCMI.
- Organizations must be aware that SCM models have greatly contributed to the business excellence in developed countries like Japan, USA, UK and Australia.
- All other impinging variables remain constant during determination of causal polarity between two variables.

Causal loop relationships

A causal loop diagram has been drawn for the SCM Index considering the supply chain opportunities and challenges as shown in Fig. 2. Positive and negative feedback loops are drawn and the relationships are obtained.

An increase in actual technology integration will tend to increase the SCM Index, which will further increase the actual technology integration. Thus the feedback loop between actual technology integration and SCM Index is positive. Similarly, all feedback loops between the actual supply chain strategies implementation, actual demand and supply integration, actual supply chain transformation, actual supply chain efficiency, actual level of achieving functional excellence and SCM Index is positive.

A decrease in actual level of technological challenges

will increase the level of the present SCM Index, which will further reduce the actual level of technological challenges. Thus the feedback loop between actual level of technological challenges and SCM Index is negative. Similarly, all feedback loops between the actual level of limited data, actual shortage of professionals, actual poor infrastructure, actual organizational model; actual supply chain network complexity, actual cultural mindset and SCM Index are negative.

An increase in the level of supply chain strategies implementation will tend to increase in actual demand and supply integration, which in turn increases the level of actual technology integration. An increase in actual technology integration will tend to increase actual functional excellence, which also tend to increase the actual supply chain efficiency. An increase in supply chain efficiency will also have a positive effect on the SCM Index. Thus the feedback loops between actual supply chain strategies implementation, actual demand and supply integration, actual technology integration, achieving functional excellence, actual supply chain efficiency and SCM Index is positive.

An increase in the level of supply chain strategies implementation will tend to decrease the gap of supply chain strategies implementation. An increase in the gap of supply chain strategies implementation will tend to reduce the actual functional excellence and increase in actual functional excellence will tend to increase the actual supply chain efficiency, which will further increase the SCM Index. Thus the feedback loop between actual supply chain strategies implementation, gap in supply chain strategies implementation, actual level of achieving functional excellence, actual supply chain efficiency and SCM Index is positive.

An increase in the level of actual demand and supply integration will tend to decrease the gap in demand and supply integration. An increase in the gap in demand and supply integration will further reduce the actual supply chain efficiency. Thus the feedback between actual demand and supply integration, gap in demand and supply integration, actual supply chain efficiency and SCM index is positive.

An increase in actual technological integration will tend to reduce the gap in technological integration. Any reduction in the gap of technological integration will increase the actual supply chain efficiency and it further increases the SCM Index. Thus the feedback loop between actual technology integration, gap in technology integration, actual supply chain efficiency and SCM Index is positive.

An increase in actual level of functional excellence will have a negative effect on its gap in achieving functional excellence. This will further increase the actual supply chain efficiency. Thus the feedback loop between the actual levels of achieving functional efficiency, gap in achieving functional excellence and SCM Index is positive.

Any increase in actual supply chain transformation will have a negative effect on its gap in supply chain transformation and this will increase the actual supply chain efficiency. Any level of increase in actual supply chain efficiency will tend to increase the SCM Index. Thus the feedback loop between the actual supply chain transformations, gap in supply chain transformation, actual supply chain efficiency and SCM Index is positive.

Increase in the level of cultural mindset among the people in a country will increase the supply chain network complexity and this will further reduce the level of SCM Index of any organization. Thus the feedback loop between the actual cultural mindset, actual supply chain network complexity and SCM Index is negative. In order to increase the present SCM Index the cultural mindset of the people living in a country should have less variation and minimal language differences. Perhaps this is one of the critical factors for India.

In order to increase the present SCM Index the cultural mindset of the people living in a country should have less variation and minimal language differences. Perhaps this is one of the critical factors for India.

An increase in the level of actual cultural mindset among the people will have a negative impact on actual level of achieving the supply chain efficiency. This will further reduce the SCM Index. Thus the feedback loop between the actual cultural mindset, actual supply chain efficiency and SCM Index is positive. An increase in the actual level of poor infrastructure of a country will have a negative impact on its actual organizational model and this will further reduce the SCM Index. Thus the feedback loop between actual poor infrastructure, actual organizational model and SCM Index is positive.

Increase in the level of actual poor infrastructure will tend to increase the actual technological challenges of a country. Increase in technological challenges will reduce the SCM Index of the country. Hence the feedback loop between the actual poor infrastructure, actual technological challenges and SCMI is negative. On the other hand increase in the actual level of technological

challenges will reduce the actual supply chain effectiveness and this will further reduce the SCMI. Thus the feedback loop between the actual poor infrastructure, actual technological challenges, actual supply chain effectiveness and SCMI is positive.

Increase in the level of cultural mindset among the people in a country will increase the supply chain network complexity and this will further increase the gap in supply chain network complexity. An increase in the gap of supply chain network complexity will tend to reduce the actual supply chain efficiency. Thus the feedback loop between actual cultural mindset, actual supply chain network complexity, gap in supply chain network complexity and SCMI is positive.

An increase in shortage of professionals will tend to increase the actual technological challenges and this will further reduce the SCM Index. Thus the feedback between actual shortage of professional, actual technological challenges and SCMI is negative. Similarly an increase in actual level of limited data will tend to increase in the actual level of technological challenges. Thus the feedback loop between actual level of limited data, actual technological challenges and SCMI is negative.

An increase in technological challenges will have a negative effect on the actual technological integration. And this will further reduce the supply chain functional excellence and thereby lead to a final reduction in SCMI. Thus the feedback loop between actual technological challenges, actual technological integration, actual functional excellence and SCMI is positive.

An increase in actual structure of an organizational model will tend to increase the gap in actual supply chain transformation across the markets. To reduce this effect an industry should have a collaborative supply chain with their supplier and customer. An increase in gap of supply chain transformation across the market will further reduce its actual supply chain effectiveness. Thus the feedback between the actual structures of organizational model, gap in supply chain transformation, actual supply chain effectiveness and SCMI is positive.

Conclusion

Casual relationships have been developed between the supply chain variables. The resulting dynamic interactions indicate that 29 feedback loops are positive and 16 loops are negative. The main purpose of developing the causal relationship for the SCM variables is to identify the dynamic interactions among these variables and to drive improvement in the present supply chain management system. Gaps in technology integration, supply chain strategies implementation, demand and supply integration, supply chain transformation, SC efficiency, achieving functional excellence, limited data, shortage of professionals, technological challenges, organizational models, poor infrastructure, supply chain network complexity, cultural mind set and SCMI have been identified as goal-seeking loops. The analysis helps the Indian auto maker to re-look their supply chain structure and to take policy decisions to improve the supply chain effectiveness. But the real improvement depends upon the practical effective implementation of the strategies. The causal loop diagram can be extended with system dynamics flow diagram and its system equations to evaluate various strategies for the effective implementation of the SCMI.

References

Adolfo Crespo Marqueza and Carol Blanchar, (2004), "The procurement of strategic parts. Analysis of a portfolio of contracts with suppliers using a system dynamics simulation model", International Journal of Production Economics, Vol 88, pp. 29 49.

Bass, B.M., McGregor, D.W. and Walters, J.L. (1977), "Selecting foreign plant sites: economic, social, and political considerations", Academy of Management Journal, Vol. 20 No. 4, pp. 535-51.

Bernhard J. Angerhofer and Marios C. Angelides (2000), "System dynamics modeling in supply chain management: research review", Proceedings of the 2000 winter simulation conference, p 342-351.

Chikan, A. and Whybark, D.C. (1990), "Cross-national comparison of production inventory management practices", Engineering Costs and Production Economics, Vol. 19 No. 1-3, pp. 149-56.

Cohen, M.A. and Lee, H.L. (1988), "Strategic analysis of integrated production distribution systems: models and methods", Operations Research, Vol. 36 No. 2, pp. 216-28.

Doz, Y.L. (1984), "Managing manufacturing rationalization within multinational companies", in Sheth and Eshgi (Eds), Global Operations Perspectives, South Western, Cincinnati, OH, pp. 2-11.

Forrester, J.W., (1961), "Industrial Dynamics", MIT Press-Cambridge, MA, USA

Forrester, J.W., (1994), "Learning through system dynamics as preparation for the 21st century", Key note address for systems thinking and dynamic modeling conference for K-12 education, Concord, MA, USA.

Goodman, M.R., (1974), "Study notes in system dynamics", Wright-Allen Press, Inc, Cambridge, MA, USA

John Sutton, (2004), "The Auto-component Supply Chain in China and India - A Benchmarking study", Report of London School of Economics and Political Science, pp. 1-48.

Khanna, V.K., Prem Vrat, Ravi Shankar, Sahay, B.S., and Ashiwini Gautam, (2003), TQM modeling of the automobile manufacturing sector: a system dynamics approach, Work Study, Vol 52, No. 2, pp. 94-101.

Klassen, R.D. and Whybark, D.C. (1994), "Barriers to the management of international operations", Journal of Operations Management, Vol. 11, pp. 385-96.

Kogut, B. (1985b), "Designing global strategies: profiting from operational flexibility", Sloan Management Review, Fall, pp. 27-38.

Lai, C.L., Lee, W.B. and Ip, W.H. (2003), "A study of system dynamics in just-in-time logistics", Journal of Materials Processing Technology, Vol 138, pp. 265-269.

Moffat, L.A.R. (1992), "Consumer electronic products: trends in European distribution", International Journal of Physical Distribution & Materials Management, Vol. 22 No. 7, pp. 13-22.

Oscar Rubiano Ovalle and Adolfo Crespo Marquez, (2003), "The effectiveness of using e-collaboration tools in the supply chain: an assessment study with system dynamics", Journal of Purchasing & Supply Management, Vol 9, pp. 151-163.

Picard, J. (1982), "Typology of physical distribution systems in multi-national corporations", International Journal of Physical Distribution & Materials Management, Vol. 12 No. 6, pp. 26-39.

Porter, M.E. (1986), "Competition in global industries: a conceptual framework", in Porter, M.E. (Ed.), Competition in Global Industries, Harvard Business School Press, Boston, MA.

Prem Vrat, (1998), "Supply Chain Management in India: Problems & Challenges", Supply Chain Management: For Global Competitiveness, Macmillan India, New Delhi, 10-24.

Satsangi, P.S., Mishra, D.S., Gaur, S.K., Singh, B.K and Jain, D.K (2003), "Kybernetes", Vol, 32, No. 5/6, pp. 808-817.

Schmenner, R.W. (1991), "International factory productivity gains", Journal of Operations Management, Vol. 10 No. 2, pp. 229-54.

Seto, H. (1988), "The cost of distribution in Britain and Japan", International Journal of Physical Distribution & Materials Management, Vol. 18 No. 4, pp. 22-31.

Shotaro Minegishi and Daniel Thiel, (2000), "System dynamics modeling and simulation of a particular food supply chain, Simulation Practice and Theory, Vol 8, pp. 321-339.

Sum, C.-C. and Yang, K.-K. (1993), "A study of manufacturing resource planning MRPII practices in Singapore", Omega, The International Journal of Management Science, Vol. 21 No. 2, pp. 187-97.

Tan, K.C. (2001), "A framework of supply chain management literature", European Journal of Purchasing and Supply Management, Vol. 7 No. 1, pp. 39-48.

Toru Higuchi and Marvin D. Troutt, (2004), "Dynamic simulation of the supply chain for a short life cycle product: Lessons from the Tamagotchi case", Computers & Operations Research, Vol 31, pp. 1097–1114.

Vargas, G.A. and Johnson, T. (1993), "An analysis of operational experience in the US/Mexico production sharing Maquiladora program", Journal of Operations Management, Vol. 11 No. 1, pp. 17-34.

□

The easiest, the most tempting, and the least creative response to conflict within an organisation is to pretend it does not exist.

– Lyle E. Schaller

Feature

Total Productive Maintenance Implementation at Tata Steel

I.P.S. Ahuja, T.P. Singh, A. Wadood & Sushil

In the wake of rapid developments taking place in the global market place, manufacturing managers are forced to reconsider the contribution and importance of virtually every key business function involved in getting a quality product to the customer. Total Productive Maintenance is the latest maintenance management tool directed at the maximization of equipment effectiveness that results in increased productivity and reduction of costs in any industrial establishment. Through this paper a case study of an Indian manufacturing organization achieving business excellence through TPM implementation has been described.

I.P.S. Ahuja and I.P. Singh are in the Dept. of Mechanical Engineering,Thapar Institute of Engineering and Technology, Patiala; A. Wadood is TPM Coordinator, Tata Bearings Division, TISCO, Kharagpur and Sushil is at the Department of Management Studies, IIT, Delhi.

The fierce pace of manufacturing technologies in recent times accompanied with short product life-cycle, high time-to-market pressure, vulnerable JIT and lean manufacturing strategies have made it critical for manufacturing companies to adapt the proactive corporate and management strategies as well as production philosophies and processes. In recent times, manufacturing industry has experienced unprecedented changes related to management perspectives, production and process technologies, drastic changes in customer expectations, supplier attitudes, competitive behaviour, besides demanding quality requirements due to global competition. The rapidly changing global marketplace calls for affecting improvements in a company's performance by focusing on cost cutting, increasing productivity levels, quality and guaranteeing deliveries in order to satisfy customers (Raouf, A., 1994).

It has now become obvious that the ability of an organization to achieve "world class" status depends largely on how well it can get all the various organizational functions to work together simultaneously rather than sequentially and how well it manages to remove the barriers of mistrust and rivalry between departments and functions, which lead to chaos, waste and loss of effectiveness. Recent competitive trends have been pushing manufacturing managers to reconsider the contribution and importance of virtually every key business function involved in getting a quality product to the customer including maintenance (Ben-Daya M. et al, 1995). Thus, there is an utmost need for integrating maintenance and operation functions through improved planning, scheduling, and cooperative team-based continuous improvement efforts for improving quality and responsiveness of maintenance services in achieving World Class Status to meet global competition that is crucial for sustainability efforts in a manufacturing organization.

In the move towards world class manufacturing

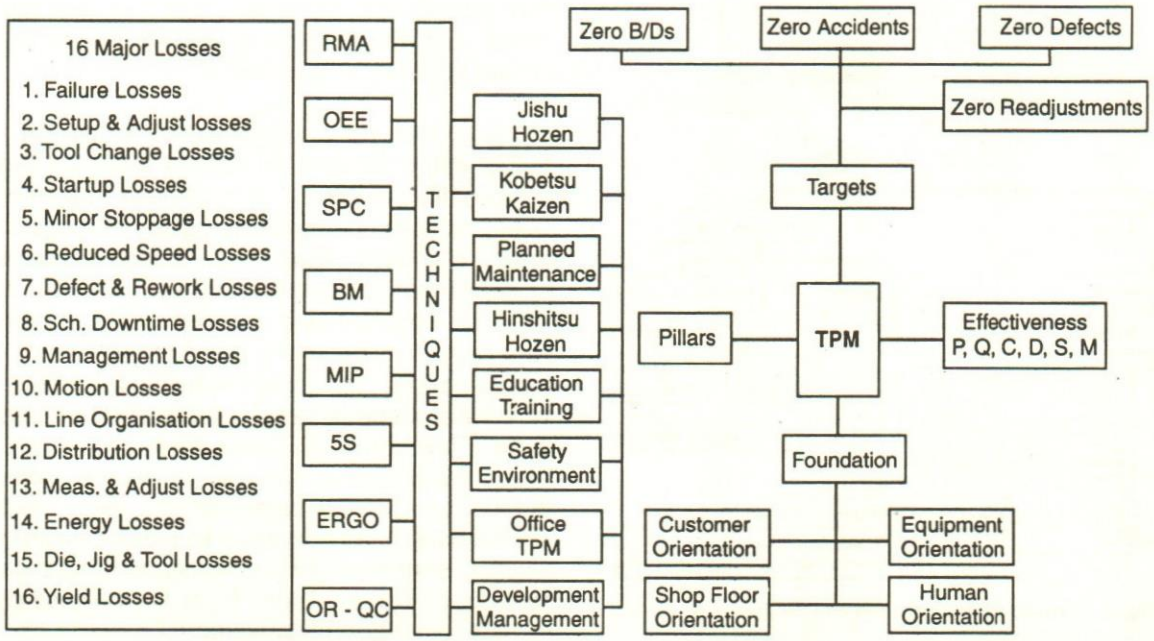


Fig. 1. Tools used in the TPM implementation programme with potential benefits accrued and targets sought

(WCM), many firms are dependant on the features and conditions of the production and manufacturing equipment and processes for improving the delivered quality of the products or services. With increased global competition, attention has been shifted from increasing efficiency by means of economies of scale and internal specialization to meeting market conditions in terms of flexibility, delivery performance and quality (Yamashina H., 1995). Maintenance, as a support function in businesses, plays an important role in backing up any emerging business and operation strategies (Kit-Fai Pun et al, 2002). To that end, the effectiveness of maintenance needs to be improved. With the trend to just-in-time (JIT) production and flexible, agile manufacturing, it is vital that maintenance becomes integrated with corporate strategy to ensure equipment availability, quality products, on-time deliveries and competitive pricing.

Total Productive Maintenance

Total productive maintenance (TPM) is the philosophy of continuous improvement and teamwork that focuses on delivering these objectives. TPM is a programme for the fundamental improvement of the maintenance functions in an organization, which involves its entire human resources. TPM is an approach to equipment management that involves employees from both production and maintenance departments. Shirose (1996) defines TPM as "the process which takes productive maintenance company-wide, based on small group activities and with the support and co-operation of managers and employees at all levels". Its purpose is to eliminate major production losses by introducing a programme of continuous and systematic improvements to production equipment. Seiichi Nakajima (1998) defines TPM as a productive maintenance carried out by all employees through small group activities.

TPM aims to increase the availability of existing equipment in a given situation, reducing in that way the need for further capital investment. Instrumental to its success is the investment in human resources which further results in better hardware utilization, higher product quality and reduced labour costs (Bohoris G.A. et al, 1995). The idea of using TPM to identify major production losses due to equipment, personnel, management, and material inefficiencies can highlight the cost drivers associated with lack of appropriate maintenance to the production system. Many of the root causes of poor asset performance are often found in support or administrative processes, so any TPM programme needs to 'cut across' these areas of the organization, though its focus is always on the performance of front line assets, and the teams that operate them. TPM is an equipment-focused improvement effort dedicated to creation of an ideal equipment state. TPM seeks to engender a company-wide approach towards achieving a standard of performance in manufacturing, in terms of the overall effectiveness of equipment, machines and processes, which is truly world class.

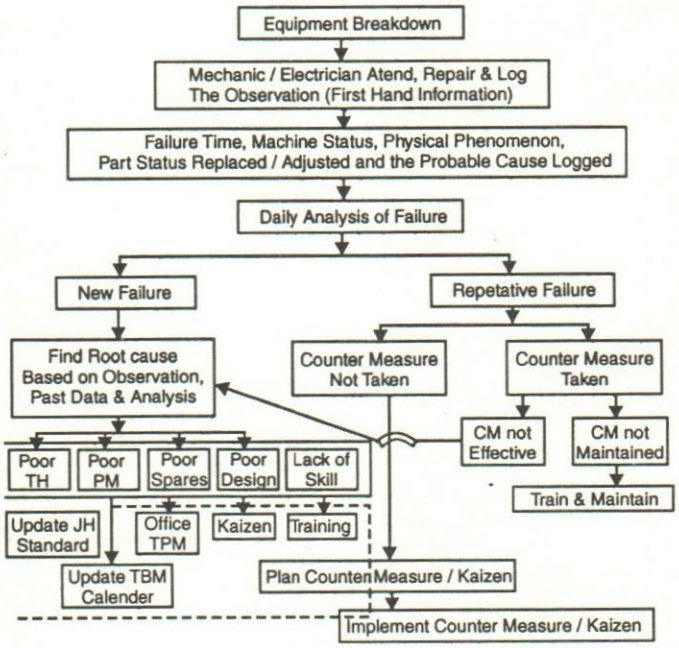


Fig. 2. Breakdown analysis and countermeasure

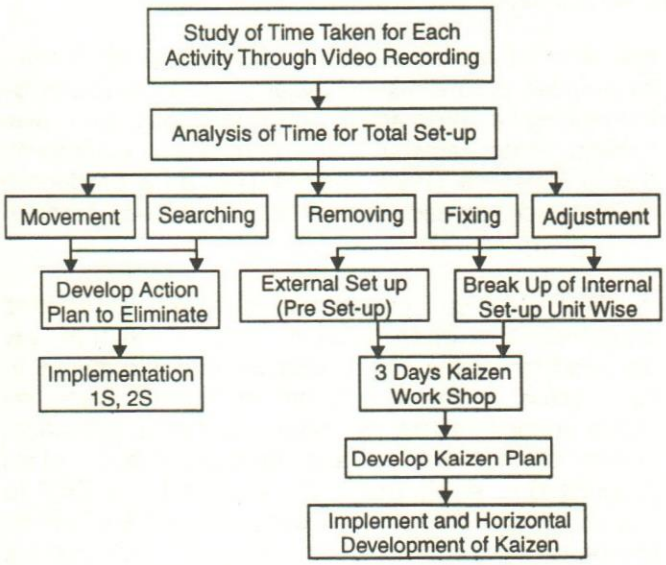


Fig. 3. Methodology for reduce set-up time

The 12 steps of TPM implementation, as suggested by Bohoris G.A. include: Announcement of top management's decision to introduce TPM; Education and campaign on the introduction of TPM; Creation of organizations to promote TPM; Establishment of basic policies and goals of TPM; Formulation of master plan for developing TPM; TPM kick-off; Improvement of effectiveness of each piece of equipment; Creation of set-up for autonomous maintenance; Creation of set-up for planned maintenance in the maintenance department; Training in improved operation and maintenance skills; Creation of set-up for initial management of equipment; and Perfect implementation and higher level of TPM. Figure – 1 shows the tools used in the TPM implementation programme along with the potential benefits accrued and the targets sought in an optimum TPM implementation programme.

TPM has been implemented in Japan since the 1970s with significant number of organizations reaping the benefits arising out of successful implementation of TPM practices and methodologies. TPM has achieved a great response from the industrial organizations worldwide since its evolution and a very large number of industrial organizations are adopting TPM programmes, especially in developed and industrialized nations. In the Indian context, the Indian industries currently are at a very initial stage of development of this technique and quite a few companies have been proactively trying to break the shackles with serious interventions. In their pursuit for TPM implementation, many Indian companies have been honoured to receive award for excellence in consistent TPM commitment-first category and award for TPM excellence from JIPM. These companies include among others: Vikram Cement Ltd. (AV Birla Group) (1995), Sundram Fasteners Limited (TVS Group) (1998), Tanfac Limited (AV Birla Group) (1999), Birla Tyres (2000), Grasim Industries Limited (2001), Grasim Industries Limited (2001), Hindustan Lever Ltd.(2001), Usha Beltron (2001), Vikram Cement Ltd. (2001), Indo Gulf Corporation Limited (2002) and Tata Metaliks Ltd (2002).

Case Study

A case study has been taken up at Tata Steel Bearing division located at Kharagpur to ascertain the status of TPM implementation in the Indian industry. The Tata group of companies is one of the oldest business groups in India and has pioneered various new ventures in the country including steel, textiles, tea, chemicals, telecom, motors, software, hotels and steel, with an annual turnover of $12,000 million. The bearing manufacturing and sales is among one of the upward integration business of Tata Steel. The major contributors leading to the organization's decision to implement TPM included among others increased competition, high cost of production, increased thrust from major market players to improve quality of products, and requirement of manufacturers to reduce delivery periods and shorten new product development time. Moreover the organization was also faced with certain inherent deficiencies affecting the sustainability of the plant that included high breakdown loss, high setup change loss of up to 8 hours per change in certain cases, high speed loss, high defect loss and high energy consumption (1.2 kWh per bearings) leading to alarmingly high manufacturing costs.

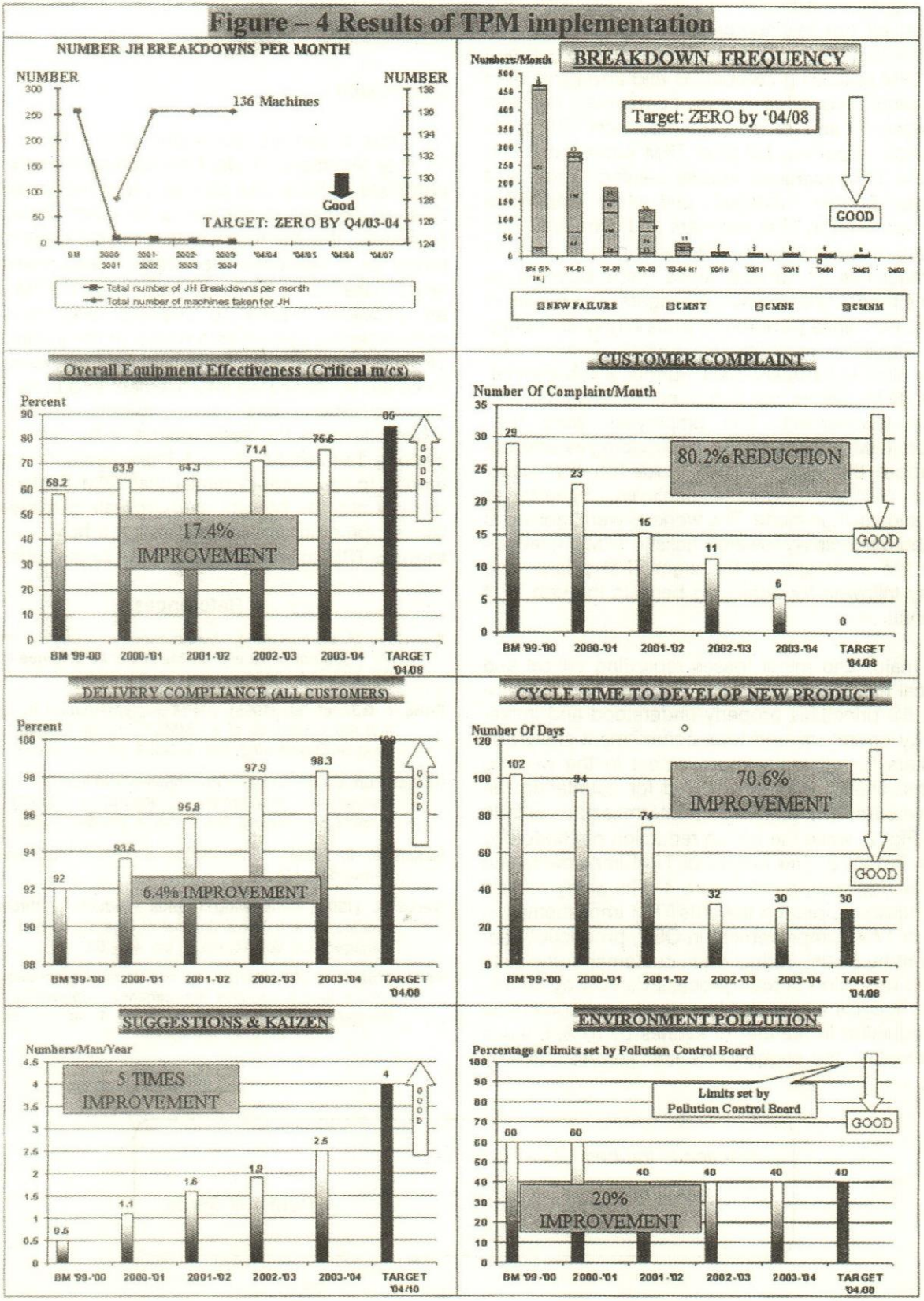


Fig. 4. Results of TPM implementation

The organization began its TPM journey with TPM declaration by top management in August 1999. It all started with joining hands with "JIPM" and organizing visits to TPM practicing companies and arranging visits of consultants. This followed a joint agreement between the management and the union to implement TPM in the organization, appoint a full time TPM coordinator and provide the TPM instructor course training to the TPM coordinator. Further managers and other employees were trained through TPM seminars and company visits to have an understanding of TPM principles. Further 12 critical machines of various areas were selected as manager's model under senior managers. The results of the model machines were found to be highly encouraging and TPM implementation was formally launched for the entire plant in February 2000. Further, 8 sub-committees, 94 TPM circles were formed to ensure 100% employee involvement. The employees were then trained on TPM principles and methodologies and apprised about the achievements made on the model machines viz. improvements achieved, benefits to workers and savings made. The workers were motivated to contribute effectively towards holistic TPM implementation in the plant and all the eight TPM pillars were rigorously followed for achieving benefits through TPM implementation.

The major and minor losses regarding critical and non-critical machines alike were identified and duly addressed, 5S principles properly understood and implemented by operators, and total commitment shown by the workers for affecting improvement in the working conditions. The procedure adopted for countering the breakdowns and the resulting countermeasures is indicated in Fig. 2, while the set-up reduction methodology is shown in Fig. 3. The results of TPM implementation are clearly depicted in the Figure 4. The study reveals that the holistic approach towards TPM implementation resulted in 17.4% improvement in OEE, productivity enhancement by 53.3%, reduction in customer complaints by 80.2%, reduction in total process defects by 86.8%, reduction in cycle time for new product development by 70.6%, reduction in number of injuries by 81%, 5 times improvement in the suggestions and kaizens, thereby leading to overall reduction in production cost of bearings by 8.4%.

Conclusion

Thus it can be concluded that TPM is not just another technique of plant management. Rather, it is a corporate culture that centres on achievement of optimal equipment performance to meet organizational objectives. It is the foundation for world-class manufacturing as it facilitates the effective implementation of world-class lean manufacturing practices. TPM provides an excellent means to improve efficiency of the manufacturing system as a whole. In the Indian context, TPM can be effectively employed as a means to supplement the concentrated improvement efforts by addressing equipment and other related problems that adversely affect the performance of the manufacturing system. The results of TPM implementation are a testimony to the huge potential that TPM implementation has got and the present study reveals that there is further scope of improvement through a holistic approach towards TPM implementation in the organization.

References

Ben-Daya M. et. al. (1995), "Maintenance and quality: the missing link", Journal of Quality in Maintenance Engineering, Vol. 1, No. 1, pp. 20 –26.

Bohoris G.A. et al. (1995), "TPM implementation in Land-Rover with the assistance of a CMMS", Journal of Quality in Maintenance Engineering, Vol. 1, No. 4, pp. 3 – 16.

Kit-Fai Pun et. al. (2002), "An effectiveness-centred approach to maintenance management", Journal of Quality in Maintenance Engineering, Vol. 8, No. 4, pp. 346 – 368.

Nakajima, S. (1988), "Introduction to TPM", Productivity Press, Cambridge, MA.

Raouf A. (1994), "Improving Capital Productivity through Maintenance", International Journal of Operations and Production Management, Vol. 14, No. 7, pp. 44 – 52.

Yamashina H. (1995), "Japanese manufacturing strategy and the role of total productive maintenance", Journal of Quality in Maintenance Engineering, Vol. 1, No. 1, pp. 27 – 38.

□

Practice is the best of all instructors.

– Publilius Syrus

Feature

Vehicle Route Scheduling Software for Distribution Planning

Amit Saxena & Chandan Bhar

Vehicle route scheduling has a very important role to play for a dairy distributing milk to its retailers. The routes of the vehicles must be decided so that the total transportation cost of milk is minimum. In order to obtain the optimum routes for the vehicles, Vehicle Route Scheduling (VRS) software has been developed. This software is based on Tyagi's algorithm for truck dispatching problem. It identifies optimum routes for the vehicles supplying milk to the retailers, and also identifies the minimum number of vehicles required to supply the desired quantity of milk to the retailers.

Amit Saxena is a student of M. Tech. programme at the Indian School of Mines, Dhanbad; and Chandan Bhar is Assistant Professor in the Department of Management Studies, Indian School of Mines, Dhanbad.

Vehicle route scheduling is one of the most important areas in the Physical Distribution Management (PDM) of any industry these days. Physical distribution is concerned with the flow of products from supplier to the customer, possibly through several stages of transportation and stocking (Smith 1989). The major area of PDM are (a) Central Warehouse location, (b) Allocation of Warehouse capacities to customer's demand (Transportation Model), (c) Vehicle Route Scheduling (Reddy and Sharma, 1995). One of the most common problems in any service system is the design of routes for vehicles or people (Paneerselvam and Balasubramanian, 1990a).

This area of study deals with how to plan the routes of distribution vehicles optimally with different constraints of cost, time, and capacity of vehicle. The large part of total distribution cost and effective management of transport function can lead to enhanced profitability both through cost reduction and through service improvements (Behra and Guin, 2003). The field of study concerns such issues like which mode of vehicle should be owned or hired, how efficiently deliveries should be made to different customers and how these deliveries should be scheduled.

In particular the development of a local delivery vehicle routing methodology is important not only to generate efficient routes to suit local circumstances, but also as it leads to an improvement in local delivery functions for the purpose of major reshaping of depot networks (Mole, 1979). The most commonly used vehicle routing problem consists of a set of uniform carriers of known capacity operating from a single depot, servicing a group of customers at fixed locations with predetermined requirements. Each customer must be satisfied with regard to demand quantity, but no bounds are placed upon the timing of individual deliveries/collections (Buxey, 1979a).

Vehicle scheduling is normally used as a planning tool with the principal objective of minimizing the number

of vehicles required to service customers from a depot. A secondary objective is to minimize the total vehicle travelling time or mileage (Cheshire et al. 1982a).

Background

Transportation Planning plays a vital role in the logistical planning of any service or manufacturing organization. Various techniques of Operations Research were applied in the past for transportation planning of many industries. A brief review of the works conducted by various authors for transportation planning is discussed below.

Clarke and Wright (1964) introduced a way of quantifying the direct link between any two points, *i* and *j* according to the potential "savings" involved. If both *i* and *j* have at least one direct connection to the depot (point 1), a new journey of length C_{ij} can be constructed to replace C_{i1} and C_{1j}, with the result that overall requirement of carriers wil be reduced by one unit. Elementary geometry indicates that the total reduction in distance travelled occurs, given by $S_{ij} = C_{i1} + C_{1j} - C_{ij}$. The opening situation designates a separate truck to each customer, and the total distance is progressively shortened, by repeatedly joining the point-pair of maximum "savings", provided the connection is feasible. This will result in reduction of one vehicle for dispatching. There exists a corollary between distance and fleet reduction, but each connection is assessed without regard to its subsequent implication. Thus considerable grounds for sub-optimization are apparent.

Tyagi (1968) formulated the truck-dispatching problem as a Traveling Salesman Problem (TSP) for which the quantity demanded at each delivery point must be known in units which defines the capacity of the truck to be used in the operation. The generated routes are such that the total distance covered by the whole fleet of trucks is minimum. Tyagi looked into additional conditions like added penalty cost for unit volume of the under-utilization of the capacity of the truck and distance travelled in the route.

Gillet and Miller (1974) developed sweep algorithm, in which groups of customers are compiled in a clockwise sweep, based on the capacity constraint alone. Entry into the route is confined to the latest aggregation, and when individual routes are created by (successive) applications of a TSP algorithm a true petal-structure is formed. Rotating the co-ordinate axes until the lead element of one ranked table becomes the last, for the anticlockwise mode, and solutions are subjected to the subsequent modification steps that generates an extensive collection of such schedules.

Bodin and Berman (1979), presented an algorithm for routing and scheduling of school buses. They assumed that the starting and ending times of all the school in the district are known and can be partitioned into distinct time periods. The problem of minimizing the capital cost to the district reduces to the problem of minimizing the maximum number of buses required in any time period. According to their work the school bus routing and scheduling system has basic components like input component, a routing component, and an output component. This system has reduced student transportation cost and avoided the problem of overcrowding in New York.

Buxey (1979b), proposed a new method derived from a combination of the well-known "savings" heuristic rule and Monte Carlo simulation. The author suggested that Monte Carlo simulation of feasible vehicle schedules might prove a powerful alternative, but it was obvious that for the sizeable problems the schedule population must be artificially constrained, both in order to take a meaningful sample and facilitate the selection process itself. This had been achieved by adopting the "savings' hierarchy, and tours formed may overlap. Finally all new links are assigned a specific direction of travel, which is also maintained, in an attempt to modify the preferred growth pattern.

All schedules evolve by random choice of point pair from the top echelon of a ranked table, subsequent replacement by the highest placed non-available link, and iteration of the routine. The heart of this technique is somewhat similar to that developed by Clarke and Wright, i.e. its function is to monitor the feasibility of the chosen new journey, at any particular juncture, for incorporation into the existing route pattern.

Cheshire, Malleson and Naccache (1982b), presented a heuristic method to solve the vehicle-scheduling problem by maintaining local optimality whilst approaching the feasible region. Most heuristic techniques for vehicle scheduling problem are primal in nature, that the solution is built up by retaining feasibility while gradually approaching optimality. They presented a technique of dual heuristic in that it retains local optimality at each step while gradually approaching feasibility. They developed this method using 17 academic test problems from various sources. These problems are all relatively small, ranging from 21 to 249 customers requiring deliveries from a single depot, using 4 to 19 vehicles. In most case the new results showed improvements over all previous methods.

Paneerselvam and Balasubramanian (1990b), discussed a heuristic algorithm for the Traveling Salesman Problem (TSP). The type of TSP considered was the

more general form in which the salesman initiates his tour from any city and visits each city at least once and returns to the starting city through the shortest possible route. They solved a case problem too by this proposed method with 8 nodes.

Chowdhary and Kanda (1993), dealth with the comparative study of vehicle routing algorithms as applied to the rationalization of routes for the "Delhi Public School" buses at Delhi in an economic and convenient manner. The main aim of modeling was to determine the number of routes and the points in each route so that the vehicles supporting all the demand travel the minimum of distance, subject to load and distance constraints on each vehicle. The solution algorithm was developed taking intc consideration three algorithms namely Tyagi's algorithm, Gillet's sweep algorithm and Bodin and Berman's algorithms.

They concluded that Tyagi's algorithm was the best in this case. This was true both in respect of run time as well as in saving per mileage per day. Another important factor, which supports Tyagi's algorithm, was the reduced number of routes. They recommended the output of Tyagi's algorithm to school management. Due to the additional constraint on the distance travelled, Gillet's as well as the Bodin and Berman's algorithms generate the unbalanced route structure.

Kulkarni and Kale (1998), propose a VAM-based heuristic algorithm for vehicle routing problem. The algorithm is based on penalty calculations. The algorithm requires data in matrix from showing costs/time/distances of one node to other nodes. Finally they proposed the VAM based procedure, which takes into consideration the penalty, which is to be paid if some nodes are not considered in the route. Finally they assigned a minimum value in the assigned row or column. The heuristic algorithm handled the problem of generation of routes of the refrigerated vehicles to the parlours. The algorithm had produced satisfactory results for the ice-cream routing problem.

Development of Vehicle Route Scheduling (VRS) Software

In this study a case had been taken up for development of a Vehicle Route Scheduling (VRS) software for a dairy. The dairy is one of the dairies of a State-owned Milk Producers Federation located in Bokaro district of Jharkhand state. The dairy used to supply milk to its surrounding region, i.e., Dhanbad and Bokaro region. The dairy delivers milk to its retail outlets through trucks. The VRS software determines the minimum number of trucks to be maintained by the dairy for supplying the desired quantity of milk to its retail outlets. The objective of the software was to minimize the total distance travelled by the fleet of trucks, while considering the capacity of trucks as constraint.

The objective of the software was to minimize the total distance travelled by the fleet of trucks, while considering the capacity of trucks as constraint.

The VRS software had been developed using Visual Basic 6.0 programming language. This software will help the planner/management in taking appropriate decisions regarding the smooth operation of the distribution of milk and will optimize the investment in the distribution network planning. This software had been developed on the basis of Tyagi's algorithm for finding optimal vehicle routes, and can be operated in any PC-AT 486 or above with VGA colour monitor. This software is very user-friendly, will ask for inputs from the user and it will generate the output in an interactive grid on screen.

Tyagi's Algorithm

The algorithm developed by Tyagi (Tyagi, 1968) is a simple one: it does not restrict the size of the problem to be solved and also the variation in the input data does not affect the solution. It stresses the maximum utilization of the capacity of the vehicle. Tyagi formulated the truck-dispatching problem as a Traveling Salesman Problem (TSP) for which quantity demanded at each delivery point must be known in units. The generated routes are such that the total distance travelled by the fleet of supplying vehicles is minimum.

The problem is split into four major heads (i) finding the number of trips, (ii) grouping the delivery points, (iii) finding the optimal tours, and (iv) identifying the carriers with different capacities.

Formulation of the problem according to Tyagi Notation.

Let p_1, p_2, ..., p_n be the n delivery points with respective demands q_1, q_2, ...q_n.

P_0 = central depot

C = capacity of each vehicle

d_{ij} = distance between points i, j.

X_{ij} = decision variable taking value 1, if i-j is on a chosen route, 0 otherwise.

The problem is to find those values of X_{ij} such that

Total distance, $T = \sum_{i,j=0}^{n} d_{ij} X_{ij}$ is minimized.

Flow Chart for Tyagi's Algorithm

The flowchart developed by Tyagi (Tyagi, 1968) is presented in Fig. 1.

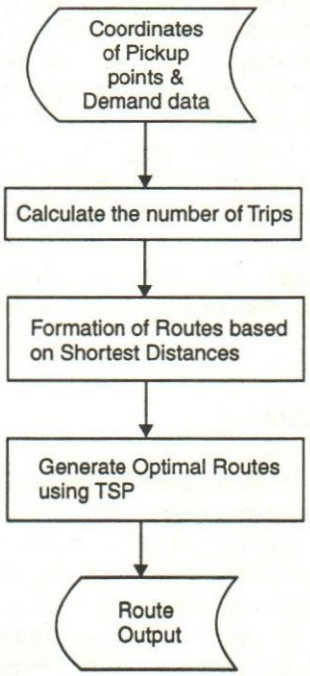


Fig. 1. Flow Chart for Tyagi's Algorithm

Systems and Software used

Microsoft Visual Studio 6.0 library had been used for the development of this software, as Microsoft Visual Basic 6.0 is an integral part of Microsoft Visual Studio 6.0 package. For handling input data Excel spreadsheets had been used. Excel spreadsheets were interfaced with the software through Microsoft Excel 9.0 Object Library. Excel spreadsheets can be opened from the software itself for editing.

Input Data Required

The whole computation requires a retailer-to-retailer and dairy-to-retailer distance matrix, number of nodes in the network, daily sale of retailers and their codes, and the capacity of vehicle serving the retailers. The software asks for inputs from user in the following sequence.

- Number of Retailers including Dairy
- Distance matrix
- Retailers Daily Sale
- Retailers Codes
- Capacity of Truck.

Output of the System

The output screen will show the output in grid by clicking one by one on switch named sub-routes till the final route of zero length and zero supply appears. The key "Print Screen" of the keyboard can print the output. The software provides the following outputs.

- Length of each sub route
- Total Supply by one vehicle in corresponding sub route
- Sub route specifying the retailers to be served by the dairy.

List of Variables

Number of variables had been used in developing the software. Some of them were temporary and some were permanent variables. Permanent variables are those, which were used to store the inputs and outputs of the software. The lists of input and output variables used in the software are presented below.

Input Variables of the Software

1.	Retailer to Retailer distance matrix	x(i,j)
2.	Retailer's daily sales	sales (i)
3.	Retailer's codes	code (i)
4.	Capacity of supplying vehicle	cap
5.	Number of retailers including dairy	ret

Output Variables of the Software

1.	Route involving retailers	s(k)
2.	Total length of the route	dist
3.	Supply of milk in the route	sum

Flow chart of the VRS Software

The flow chart of the software is presented in Fig. 2.

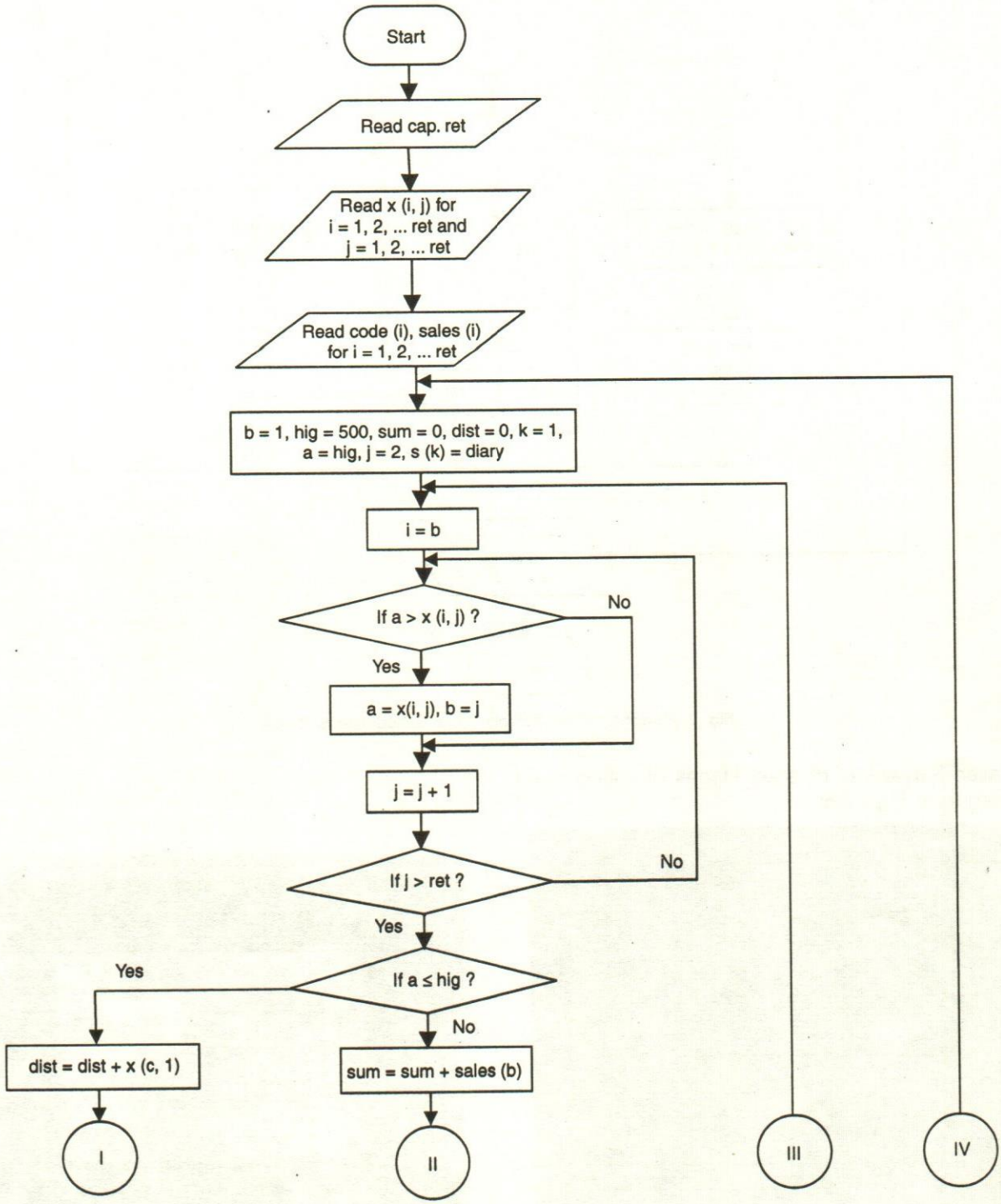


Fig. 2. Flowchart of the Vehicle Route Scheduling Software (Contd.)

Testing of the Software

The software had been tested with simulated data due to non-availability of real life data. The distance data of retailer-to-retailer distances and their daily sales had been generated by using random number generation technique. The software had been tested with a simulated distribution network consisting of twenty node points, i.e., 19 demand points (retailers) and one dairy. The distance matrix and retailer's daily sales and retailer's codes had been stored in two Excel spreadsheets in one file. The output generated during testing of the software presented five-sub routes with a supplying vehicle capacity of 1000 litres for supplying milk to

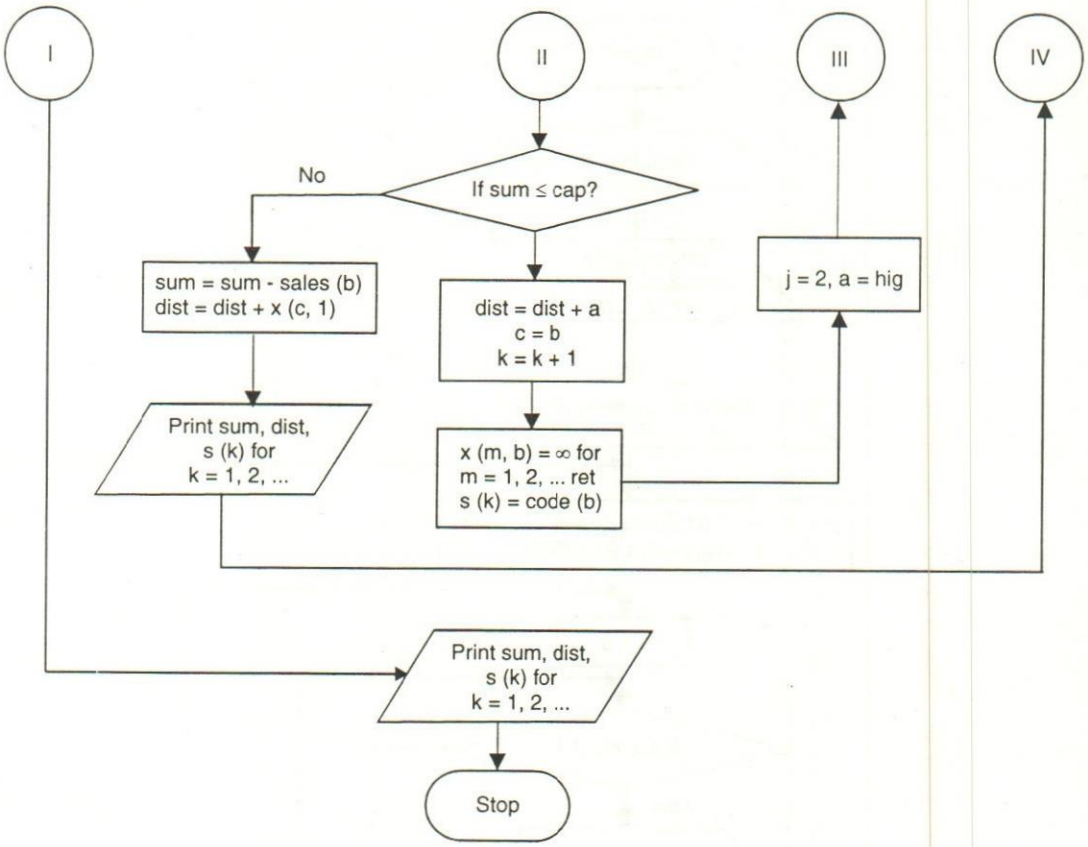


Fig. 2. Flowchart of the Vehicle Route Scheduling Software

the retailer. Screens of different stages of software are presented from Figs. 3-6.

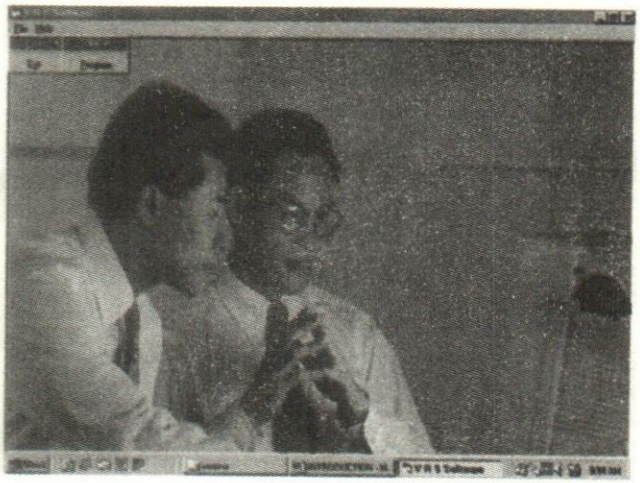


Fig. 3. Opening Screen of The Software

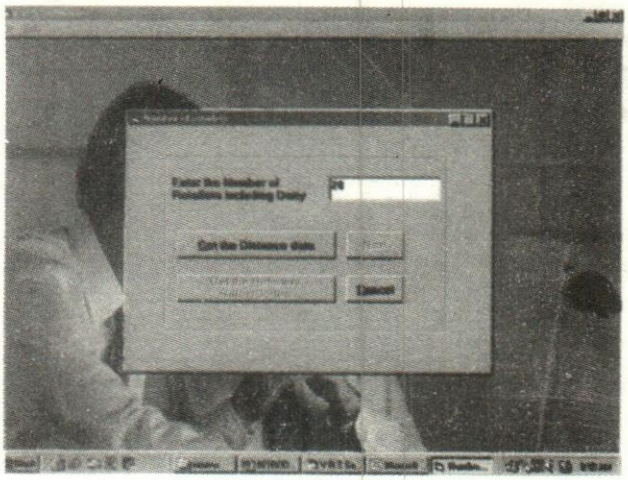


Fig. 4. First Input Screen of The Software

Software Characteristics

The present software had been developed within a limited time period. The software was yet to be evaluated by the real life user. However certain merits can be claimed and certain demerits may be accepted as stated below:

Merits

- The VRS software has got the following merits:

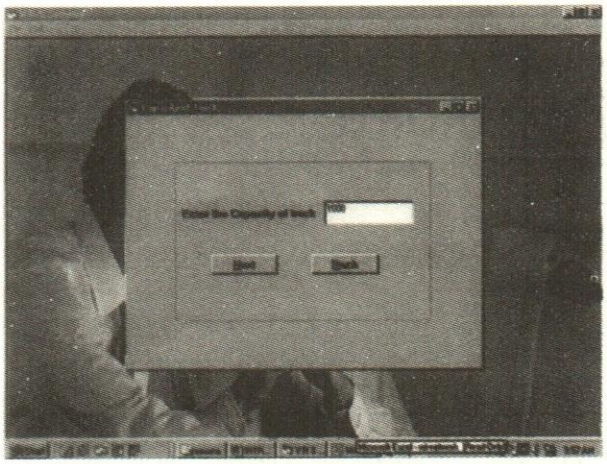


Fig. 5. Second Input Screen of The Software

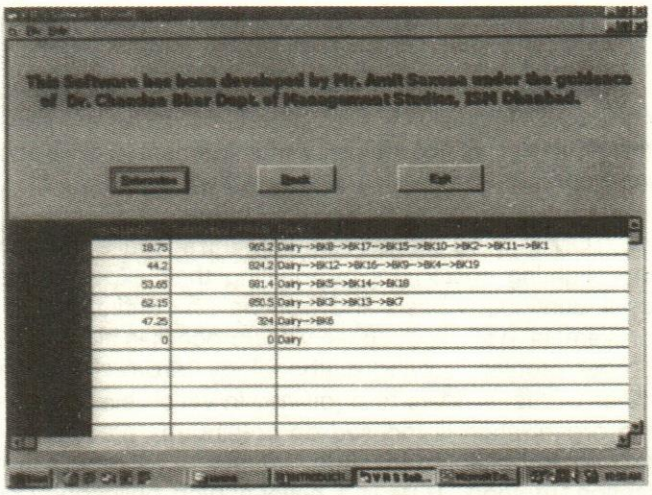


Fig. 6. Output Screen of The Software

- Simple,
- Accurate,
- Speedy/Quick reporting,
- Easy to use, and
- No expertise is required to run the software

Demerits

- It cannot work for more than 300 node points,
- It can generate only 100 sub routes in one run,
- Capacity of vehicle once fixed cannot be varied among the sub routes, and
- Due to non-availability of real life data it was not possible to validate the results.

Conclusion

Vehicle Route Scheduling plays a very important role in physical distribution management. In this study a case had been taken up for transporting planning of vehicles of a dairy located in Bokaro district of Jharkhand state for supplying milk to its retailers located in surrounding regions. In order to optimize the distance travelled by the vehicles for supplying milk, Vehicle Route Scheduling (VRS) software had been developed. This software is based on Tyagi's algorithm and had been developed using Visual Basic 6.0 language. The software is very simple and user friendly. It will help the management of the dairy to determine the optimum routes for the vehicles for supplying milk to its retailers. This software will also help the management to determine the minimum number of vehicles required to supply the desired quantity of milk to its retailers. Ultimately this software will benefit the dairy by minimizing its transportation cost of milk.

References

Behra, U.K. and Guin, K.K. (2003), "Optimization Approaches for Logistics Planning–A Case Study", Industrial Engineering Journal, Vol. 32, No. 1, pp. 5-12.

Bodin, L. and Berman, L. (1979), "Routing and Scheduling of School Buses by Computer", Transportation Science, Vol. 13, pp. 113-129.

Buxey, G.M. (1979), "The Vehicle Scheduling Problem and Monte Carlo Simulation", Jouranal of Operational Research Society, Vol. 30, pp. 563-573.

Cheshire, I.M., Malleson, A.M. and Naccache P.F. (1982), "A Dual Heuristics for Vehicle Scheduling", Journal of Operational Society, Vol. 33, pp. 51-61.

Chowdhary, B.V. and Kanda, A. (1968), "A Comparative Study of Vehicle Routing Algorithms in the Design of Bus Routes for a Delhi School", IE Journal, Vol. 22, pp. 1-9.

Clarke, G. and Wright, J.W. (1964), "Scheduling of Vehicles from a Single Depot to a Number of Delivery Points", Operations research, Vol. 12, pp. 658-581.

Gillet, B.E., and Miller, L.R. (1974), "A Heuristic Algorithm for Vehicle-Dispatch Problem", Operations Research, Vol. 22, pp. 340-349.

Kulkarni, R.V., and Kale, V.M. (1998), "A 'VAM' based Heuristic Algorithm for Vehicle Routing Problem', IE Journal, Vol. 27, pp. 5-7.

Mole, R.H. (1979), "A Survey of Local Delivery Vehicle Routing Methodology", Jouranal of Operations Research Society, Vol. 30, No. 3, pp. 245-252.

Paneerselvam, R. and Balasubramaniam, K.N. (1990), "Heuristic Algorithm for Traveling Salesman Problem and its Application to a Case Study", I.E. Journal, Vol. 19, pp. 5.14.

Tyagi, M.S. (1968), "A Practical Method for Truck Dispatching Problem", Operation Research Society of Japan, Vol. 10, No. 3 & 4.

Reddy, C.N. and Sharma, B.D. (1995), "Physical Distribution System with Software package for Route Scheduling" I.E. Journal, Vol. 24, pp. 5-8.

Smith, B. Spencer (1989), "Computer Based Production and Inventory Control", Prentice Hall, New Jersey. □

Feature

Competitiveness of Service Sector through TQM Principles

S.S. Mahapatra & K. Soma Sekhar

Manufacturing organizations have accepted TQM principles as a competitive weapon to have an edge in the market place, but the implementation level in service organizations is not encouraging, due to difficulties encountered is identifying the end-customers. In this paper, an attempt has been made to define the customers in an educational setting and to suggest a broad methodology applicable to service organizations for fostering competitiveness through adoption of TQM principles. Finally, a case study in an educational (technical) establishment has been undertaken to demonstrate the applicability of the methodology.

S.S. Mahapatra is an Assistant Professor and K. Soma Sekhar is a M.Tech. student in the Department of Mechanical Engineering of National Institute of Technology, Rourkela.

In today's competitive environment, quality is the key to an organization's success and survival. The pragmatic view of assuring quality through controlling the tolerance levels is no more applicable. Rather, the organization's emphasis is on changing the mindset of the people from "errors are inevitable" to "doing the things right, the first time and every time". In order to compete effectively, the organizations must embrace the principles of Total Quality Management (TQM) and incorporate them, into all of their activities.

TQM may be defined as an organizational approach in delighting customers by meeting their expectations on a continuous basis and working on continuous improvement in all products/services/processes along with proper problem solving methodology (Arora, 1998). In other words, it refers to a journey in which everyone in the organization is focused on continuous process improvement, directed towards increased customer satisfaction. In short, TQM is a never-ending philosophy of change for the better.

In recent years, it has been observed that TQM has become a way of life not only in manufacturing but also in the service sectors. However, implementation of TQM hardly matches with the rapid growth rate of service sectors in spite of the fact that service organizations account for almost two-thirds of the private, non-governmental workforce (Feigenbaum, 1991). This can be attributed to mainly two reasons – one being the ignorance about the sweet fruits of TQM on part of the service organizations and secondly the difficulties in distinguishing the product and the customer, as in the case of educational setting. The service industries basically range from medical assistance, specialized education, and urban transit through mail order supplies, fast food restaurants and recreational facilities.

The education establishments, particularly technical institutions, play a vital role not only in educating the

students on TQM principles but also in implementing these concepts for their own survival and improvement. The educational institutions in India must implement the principles of TQM due to the changing student demographics, diminishing government funding, and dramatically increased competition. In the West, the educational institutions have already discovered the need for TQM implementation. Results of a recent study reveal that 206 colleges and universities, 74 community colleges, and 135 K-12 school districts in the USA have implemented or are implementing either quality improvement practices in their administrations or quality related courses in their curricula or both (Rubach, 1994). Since the educational institutions deal with multiple levels of customers, they must address, in some fashion, the needs and concerns of all customers. The measurement of customer satisfaction is regarded as one of greatest challenges by the educators in an educational establishment (Cloutier and Richards, 1994). What is peculiar to educators is the role of students as customers, who should be heard, yet not being educated may not be capable of judging whether their education is being poorly imparted and delivered.

With resources becoming more limited, efficiency and effectiveness in meeting the needs of the customers becomes crucial for existence. The purpose of this paper is to demonstrate how Quality Function Deployment (QFD) and Analytical Hierarchy Process (AHP) methods can be combined in a novel way to measure customer satisfaction in an educational institution. Specifically, this paper discusses the application of QFD in a technical education setting in order to identify the customer needs and policies that need to be formulated to satisfy their needs.

Review of Literature

TQM results in higher quality, lower cost products and services that respond faster to the needs of the customer. In the context of today's business world, the object of customer service is to provide goods or services that meet or exceed customer requirement (Marchese, 1993). Implementation of TQM in education also requires a customer-driven focus. Nevertheless, the basic question lies in the identification of customers in an educational setting. In the new paradigm of education, students are treated as primary customers and a partnership between faculty and students needs to be fostered in a discovery and learning process (Brower, 1994).

Several quality initiatives are happening as universities are faced with diminishing financial support from public sources of finance. It is suggested that higher education should look to private sector models; the importance of recognizing key performance indicators on their own can be dysfunctional unless they are grounded within the culture of a strategy-focused organization (Cullen et. al., 2003).

The goal of the collaborative TQM process is to create an environment that is not just user-friendly but user-seductive, an environment that allows the instructor and students to really become excited about their work. Few researchers are reluctant to define the student as the primary customer. In their view, the goal of each office is to meet or exceed the expectations of its internal customers (Marchese, 1991). Since, the issue of who is the end customer or the primary customer is not resolved yet, it necessitates careful attention for implementing TQM practices.

As the students' are primary customers, the practice of student evaluation of teaching effectiveness is followed at some colleges and universities. However, it is debated that this instrument often fails to capture the lecturer's ability to foster the creation of learning and serve as a tool for improving instruction. (Charles et al. 2003).

As a matter of fact, there is an all-round feeling that education is too process-centered and not sufficiently student-centered (Rhodes, 1992). The student-centered view allows treating the students as customers when they are recipients of services like registration, parking, library or food. However, the customer analogy seems to be inappropriate when applied to students as the recipient of education. The student becomes the raw material of a specific process of production. In other words, the educational institutions provide the added value between the suppliers of students and the employers of their students (Ewell, 1993). Since students are both customer and product, they are valuable export to employers and community. Therefore, it may be concluded that the stakeholders, particularly of technical education, include students, alumni, employers, the academic disciplinary community, the professional community, and the economic areas and regions served by the technical institutions. Each will have their own definition of satisfaction, and each definition must be known and effectively addressed. However, the key stakeholder often has been identified as the student (Schmidt, 2002).

Since students are both customer and product, they are valuable export to employers and community.

Methodology

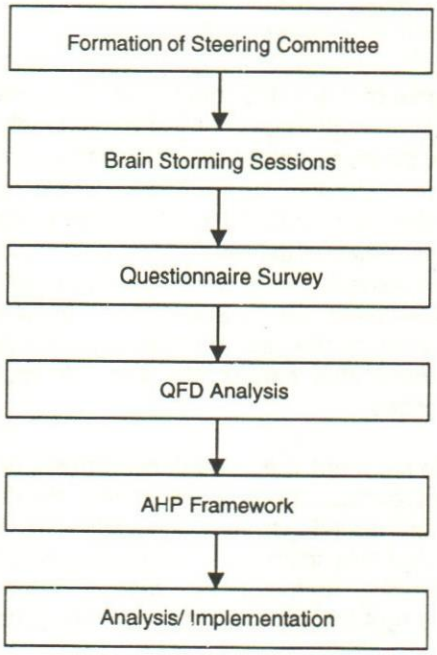


Fig. 1. A Framework for quality Improvement

The methodology adopted in this study is broadly shown in Fig.1. At the outset, a cross-functional group with members from different sections of stakeholders is formed and named as a steering committee. The steering committee is assigned the responsibility of monitoring and executing the implementation process of quality improvement. In order to identify the enabling tools for quality improvement in a specific situation, few brain storming sessions involving all the stake holders may be organized and finally a cause and effect relations need to be ascertained using the Fishbone Diagram or Ishiwaka Diagram. This results in simplification of the most difficult task of identification of areas that need to be improved. It not only provides vital information but also forms a strong base for the rest of the process. Therefore, it is of foremost importance to analyse this step with utmost care.

The fishbone diagram, one of the seven basic tools of Japanese quality, is an analysis tool that provides a systematic way of looking at effects and the causes that create or contribute to those effects. It focuses on causes rather than symptoms of a problem leading to increased understanding of a complex problem. A typical cause and effect diagram or Ishiwaka diagram is shown in Fig. 2.

In the second step, usually a pilot survey is conducted to identify the needs of the stakeholders. The questionnaires are prepared keeping in view all the stakeholders needs and include all the aspects of an ideal educational institution. The committee then analyses the feedback thoroughly, through various brainstorming sessions.

The following could be the typical findings of the feedback from two sections of stakeholders, namely students and faculties. A similar exercise can be extended to other stakeholders also.

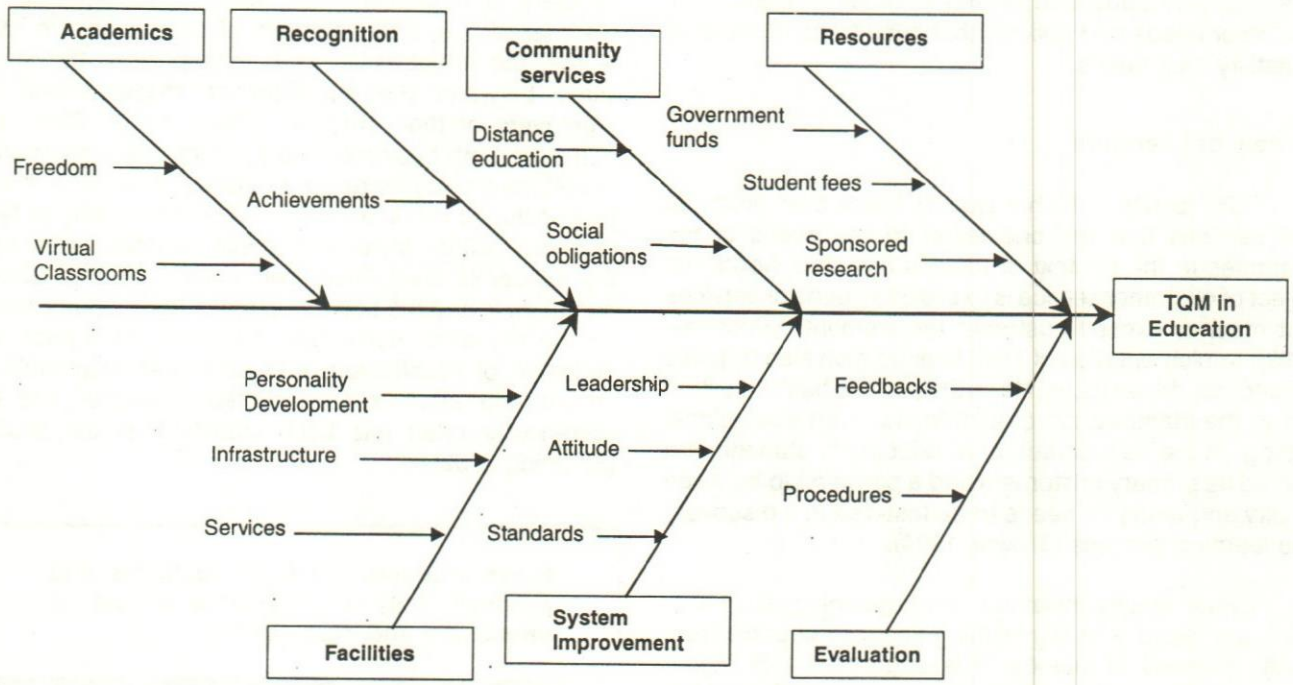


Fig. 2. A typical Fishbone Diagram

Students feel the system should provide:-

1. Congenial atmosphere for knowledge enhancement
2. Easy access to resources
3. Interactive classroom teaching
4. High quality of imparting education
5. Good services
6. Opportunity for personality development

Faculties feel that the factors that affect their teaching are:-

1. Provision of orientation programme for new teachers
2. Provision of teacher training courses
3. Access to teaching resources
4. Opportunity to meet and share experiences with other teachers teaching the same subject
5. The existence of an open and fair system in the evaluation of teacher's performance
6. Access to student feedback (including student complaints)
7. The need to comply to numerous rules and regulations in the administrative system
8. Physical environment such as classroom setting, air-conditioning, level of lighting, background noise level, etc.
9. Amenities such as resting place for teachers, drinking machine, workstation, etc.
10. Facilities such as white board, audio visual aids, computers, and Internet accessibility etc.
11. Logistic support such as access to library services, photocopying of handouts, repair service for faulty equipment etc.

In the third step, QFD analysis is carried out to rank the design requirements devised for the customer needs. QFD is a quality assurance system that helps to ensure that the voice of the customer is clearly heard and followed in the development of a product or service. Normally, the customers express their requirements in vague linguistic terms, which are difficult to understand. However, the application of QFD eases out the process of translating customer attributes into engineering or quality characteristics.

For identifying the customers, the organization must objectively determine the group or groups that best describe its current desired customer base. After the customer base has been identified, the wants of the customers are determined. These wants are commonly referred to as the "whats" and can be derived using a variety of methods. When collecting these wants, it is critical for the organization to use the terms, phases, and language of the customer. Therefore, the best way to obtain the "whats" is through the interview/questionnaire survey. As the "whats" are plentiful, the steering committee will combine all duplicate terms and group them based on similar characteristics. After consolidating the "whats", the steering committee works with customers to determine customer priorities.

The steering committee then determines the mechanisms that would satisfy these "whats". These mechanisms are commonly referred to as the "hows". Whereas the "whats" are expressed in customer terms, the "hows" are expressed in technical terms. All the "hows" will not be selected for implementation. Rather, the steering committee decides which ones are selected using a technical importance rating based on the number of "whats", to which each "how" contributes. With the "whats" and "hows" in place, the steering committee then establishes relationships between them. They assign a strength value of none, weak, medium, or strong to each relationship. Furthermore, the committee will also assess each "how" with respect to its interaction with the other "hows" to determine if there is positive, negative, or no correlation.

Finally, the steering committee incorporates all this information on a graphical display known as the "House of Quality". This house provides a framework that guides the committee through the QFD process. It is a matrix that identifies the "whats", the "hows", the relationship between them, and criteria for deciding which of the "hows" will provide the greatest customer satisfaction. The peak of the house identifies the interrelationships between the "hows". Sometimes organizations need to carry this process further by using multiple houses of quality. In such case, the "hows" of the first house become the "whats" of the second house, and the process repeats itself. When the house of quality is complete, the steering committee can then analyse and use it to achieve a product/service realization that will allow the organization to enjoy greater customer and employee satisfacation, improved product performance, and enhanced profitability.

In the final step, various strategies that are likely to be adopted to achieve the design requirements (identified in the previous step) are recognized and ranked using the Analytical Hierarchy Process (AHP). The AHP

is a powerful and flexible decision-making process to help set priorities of alternatives (or strategies) and eases out the decision-making process in a multi-attribute decision making situation. By reducing complex decisions to a series of one-on-one comparisons, then synthesizing the results, AHP not only helps the decision maker to come to the best decision, but also provides a clear rationale that it is the best.

The Case Study

Technical institutions or educational institutions, in general, aim at preparing their students to develop the ability to adapt with changing and growing technology, provide the opportunity to exhibit their full potential, and create a sense of innovation in them. Essentially, education is a process of moulding the students as self-reliant individuals. If the institution is viewed as a production process, then raw minds enter it and come out as qualified persons. The students are treated as products and also primary customers to an educational institution, which provides various services to them. The students need to pay a substantial amount in monetary terms to the institution for availing these facilities. Therefore, the voices of the students must be heard by the management of the institution while formulating the organizational policies and developing the facilities.

Education is a process of moulding the students as self-reliant individuals.

The quality of education that the institution imparts, determines the richness of the knowledge possessed by their students. The quantum of knowledge acquired by the students has a direct bearing on their market value. Rapid growth of knowledge workers compelled the institutions to consider the development of necessary infrastructure for imparting quality education. Moreover, the educational institutions are recognized by the achievements of their students. Since the technical educational establishments are mushrooming these days, institutions must impart quality education to have a competitive edge over others for their own survival.

Recently, the government funding to academic institutions has been diminished largely. The institutions are advised to generate the funds from various sources for meeting their expenses towards infrastructure development and recurring expenditure. The best ways by which the institutions can be self-supporting is through the development of methodologies for improving the quality of education/research and establishing a brand image of their own. Sometimes, the apathetic attitude of the administration to meet the requirements of the students and faculties gives rise to dissatisfaction among them. This results in failure to achieve the institutional objectives resulting in loss of "Credibility of the Organization". Several institutions try to maintain the status quo with a false impression that what they are doing is the best. Such institutions rarely accept the continuous improvement aspect of TQM and hardly upgrade themselves to meet the challenges of the changing scenario. The basic existence of the educational institutions is, at present, at stake due to foreign universities now operating in India.

A case study has been undertaken in a reputed technical institution of Eastern India. The institution offers B.Tech., M.Tech. and Ph.D courses in nine core engineering branches apart from M.Sc. and Ph.D in three basic science disciplines. The institution is recognised as a Centre of excellence by the All India Council of Technical Education (AICTE), QIP Centre for few engineering disciplines and most of the B. E. courses have obtained "A" grade by AICTE accreditation committee. Few departments are also engaged in active research, industrial consultancy, and project works offered by various funding agencies, notably the Ministry of Human Resources Development (MHRD). This is one of the oldest institutions in the region. The present annual intake capacity and faculty strength are 450 and 180 respectively. There are 300 supporting staff (technical and non-technical) working in this institution. In addition to teaching departments, several service departments like Hall Management, Students Activity Centre (SAC), Training and Placement Department, Examination Centre, etc. exist in the institution.

The institution is an autonomous body run by a Board of Governors (BOG). The head of the institution takes care of the day-to-day affairs with the advice of four Deans. The authorities now feel that the students and faculties are highly dissatisfied with the prevalent academic activities and the facilities. In order to enhance the academic standards, the authority intends to understand the voice of customers and completely redesign the existing system in terms of facilities. Therefore, a team of nine members representing major engineering branches, hall management and Students Activity Centre has been formed under the leadership of Dean (Academic Affairs). The objective of the study the team has undertaken, is to highlight the following facts:

- Customer Needs and System Design Requirements
- Specific Problems associated with imparting Quality Education.

- Policies need to be formulated to alleviate the identified limitations.

In order to obtain relevant and useful information from the study, the team has adopted the QFD method since it is frequently used in various decision-making problems due to its versatility (Pitman et. al., 1996, Prasad, 1995). The following assumptions are made to simplify the task.

- Environment factors such as cultural activities, sanitary facilities, health-care services, recreational and fooding facilities are not explicitly considered.
- Factors related to work culture such as reduction of incidence of supporting staff and higher authorities, harmonious relationship between students and faculties are not explicitly considered.
- Factors contributing to academic activities are only of importance.
- The students are considered as products as well as customers.

The team selects various system design requirements to satisfy these needs. The customer needs and system design requirements are explained below.

A. Customer Needs

Different needs of students are listed below:-

1.	Facilities	Excellent IT, library, buildings, opportunity for self-development, self-expression, knowledge enhance-ment and skill acquisition and professional growth.
2.	Academics	Knowledgeable faculty in different areas of specialization having proficiency of effective communication, state-of-the art course curriculum.
3.	Resources	Sufficient financial support for planned growth and recurring expenditure.
4.	Community Services	Commitments towards the society that supports its existence.
5.	Recognition	A foolproof mechanism to recognise the achievers and motivate the slow performers to achieve perfection and excellence both in academic and non-academic activities of the institute.
6.	System Improve-ment	Excellence at par with national and international forerunners in the field of technical education.
7.	Evaluation	Assessment of performance indicators at various levels and stages to generate the existing scenario and methods to obtain better results

B. System Design Requirements

Keeping in view of the above stated needs as customer attributes, the following system design requirements with characteristics explained for each are considered. It must be noted that the list is neither complete nor sufficient since the consideration of system design requirements is purely situation-specific. The following requirements are chosen only to demonstrate the methodology:-

1.	Infra-structure	Laboratories with sophisticated machines, equipment, accessories and consumables for pursuing research and classroom teaching, aesthetic looking buildings with sufficient floor space, neat and clean hostel facilities, well equipped sports and gymnasium, modern automated latest edition books and journals library.
2.	Personality Develop-ment	Opportunities to develop hidden skills/ talents in continuation of their pervious education and communication skills.
3.	Services	Basic medical service in the campus and additional tie-ups with specialists off the campus, excellent pharmacy, good ambient, sufficient floor space and neat canteen, well equipped stores with textbooks and other stationery.
4.	Job Opportu-nities	Capability to attract companies for campus selections, better hospitality for interviewers, emphasis on software training, rigorous practical training, industrial visits, and concept of teamwork.

5. Motivated Faculty — Important attributes that motivate faculty may be work time flexibility, growth opportunities, flexibility in course content, reduction of incidence of authority, reduction of file follow-up, transparency in administration, mutual trust and belief.

6. Freedom — Opportunities in flexibility in time, flexibility in courses, after class help, interaction with academicians.

7. Virtual Class Rooms — On-line course modules with less paper transactions.

8. Funds — Adequate financial support from government, public and private sector enterprises, student fees to meet the vision and mission of the institute.

9. Sponsored Research — Promotion of industrial consul-tancy and testing,industry based student projects, public funded projects.

10. Social obligations — Need-based scientific and indus-trial research, development of indigenous products for import substitution, rural orientation in technology innovations, community services like adoption of villages and popularisation of science and technology for improving quality of life, distance education courses.

11. Achievements — Promotional or financial advantage to performers and achievers in both academic and non-academic areas.

12. Attitude — Approach to develop positive attitude towards work/service through interaction, quick disposal of disputes by involvement of concerned parties.

13. Standards — Standardisation of administrative methods and procedures adopted, facilities to deliver the standardised outputs, international norms to be adopted at various stages of providing services.

14. Leadership — Leaders deserve to be role models, set realistic benchmarks, be approachable, capable of providing guidance and advice, pleasing personality, soothing behaviour, fast decision making, transparency in administration, delegation of authority, sincerity, dedication, capable of taking bold and courageous decisions.

15. Feedback — Collection of data of the existing system from all the concerned in the organization to pinpoint fallacies and take necessary steps, as in a closed loop control system for ensuring optimum results.

16. Procedures — Review of various methodologies used in teaching

The resulting House Of Quality (HOQ) is shown in Fig. 3. The ratings of top five system design requirements are normalized to carry out further analysis in AHP framework. The top five system design requirements serve as criteria as shown in Fig. 4. The various alternatives/ strategies formulated are as follows:

- Money Mobilisation
- TQM centre
- Change of leadership
- Industrial Collaborations/Research and Technology Development Cell
- Simplified procedures, visibility and transparency

Results & Discussion

First of all the revised customer ratings for the attributes/needs are determined from the left correlation matrix of Fig. 1.

$$\text{Customer Rating}_i = Z_i + \left[\frac{1}{(n-1)}\right] * \sum_{j \neq i}^{n} B_{ij} Z_j \qquad \ldots(1)$$

Where B_{ij} and denote the relationship between customer needs i and j

Z_i the initial customer rating

The revised rating for the second customer need is calculated as follows when the initial customer rating is 9.

$$\text{Revised Rating} = 9 + \frac{1}{(7-1)} \times [10\times0.8 + 8\times0.6 + 3\times0.6 + 6\times0.8 + 7\times0.2 + 4\times0.6] = 12.86667$$

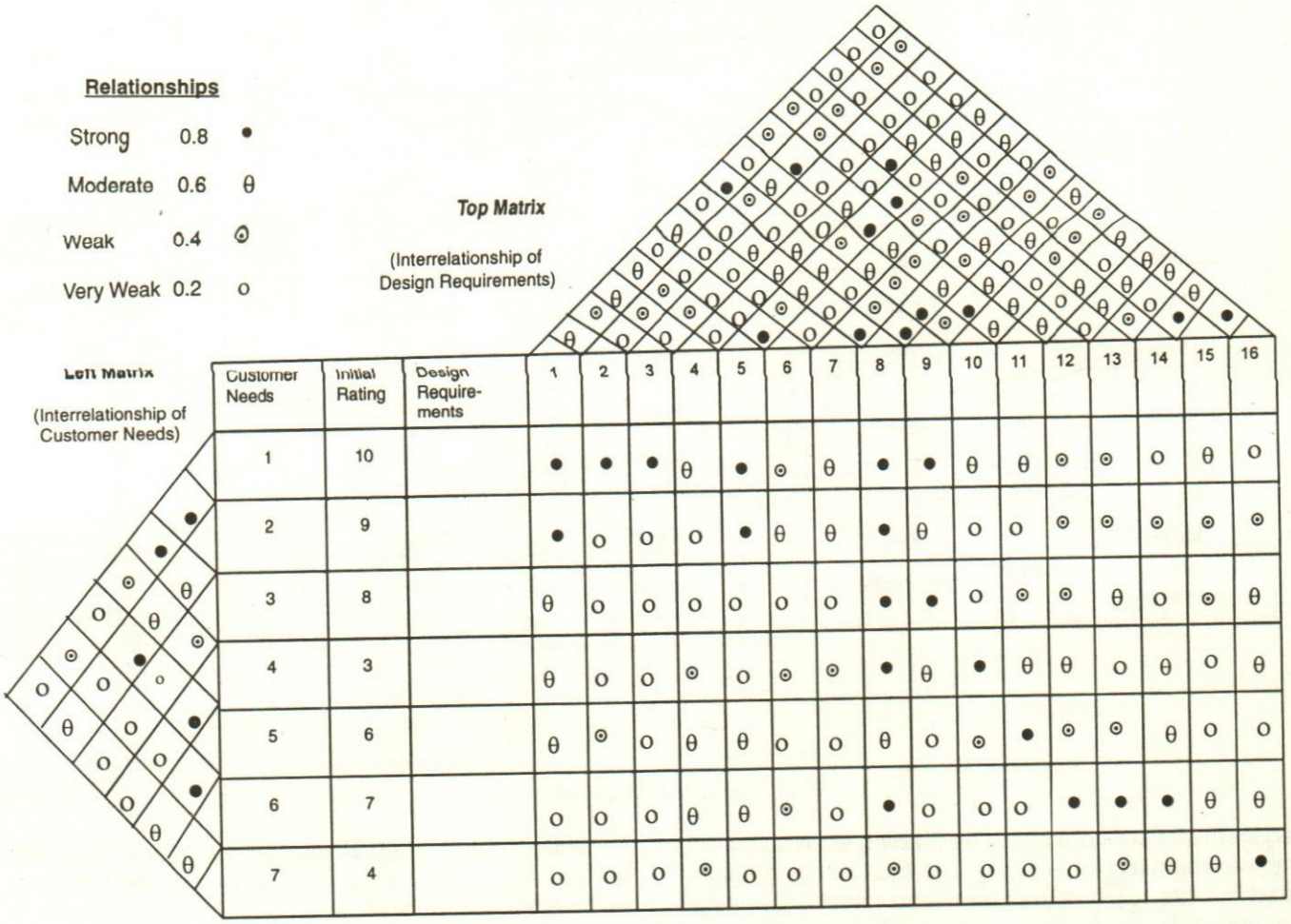


Fig. 3. A Typical House of Quality

The individual rating of each Design Requirement is obtained using the following relation.

$$\text{Individual Rating}_i = \frac{1}{n} \times \left(\sum_{j}^{n} A_{ij} X_j \right) \quad \ldots(2)$$

where A_{ij} and X_j denote the relative importance of the i^{th} characteristic with respect to the j^{th} customer need in the relationship matrix and the importance of the j^{th} customer need perceived by customer i.e. customer rating and n is the number of customer needs.

Individual Rating of design requirement 1 =

$$\frac{1}{7} \times (13.26667 \times 0.8 + 12.86667 \times 0.8 + 11.00000 \times 0.6 + 6.26667 \times 0.6 + 9.53333 \times 0.6 + 9.53333 \times 0.2 + 6.90000 \times 0.2)$$

$$= 5.75333$$

Then revised rating for each design requirement is calculated in a similar fashion as it is calculated for customer needs using Equation 1. The final ratings of design

Table. 1: Normalised Refined Ratings of Design Requirements

Customer Requirements	Individual Ratings of Customer Requirements	Design Requirements (as shown in section 4)	Individual Ratings of Design Requirements	The Refined Ratings
Facilities	13.26667	1	5.75333	7.45117
Academics	12.86667	2	3.39143	5.09539
Resources	11.00000	3	3.11905	4.49967
Community services	6.26667	4	5.25524	7.25242
Recognition	9.53333	5	5.80476	8.55633
System Improvement	9.53333	6	3.86190	5.56684
Evaluation	6.90000	7	4.28286	6.05882
		8	7.26095	9.37970
		9	5.70000	8.14058
		10	3.54952	5.62135
		11	4.22952	6.81644
		12	4.49048	6.67126
		13	4.73905	6.27262
		14	5.15714	7.51540
		15	4.36095	6.23500
		16	4.47238	6.76587

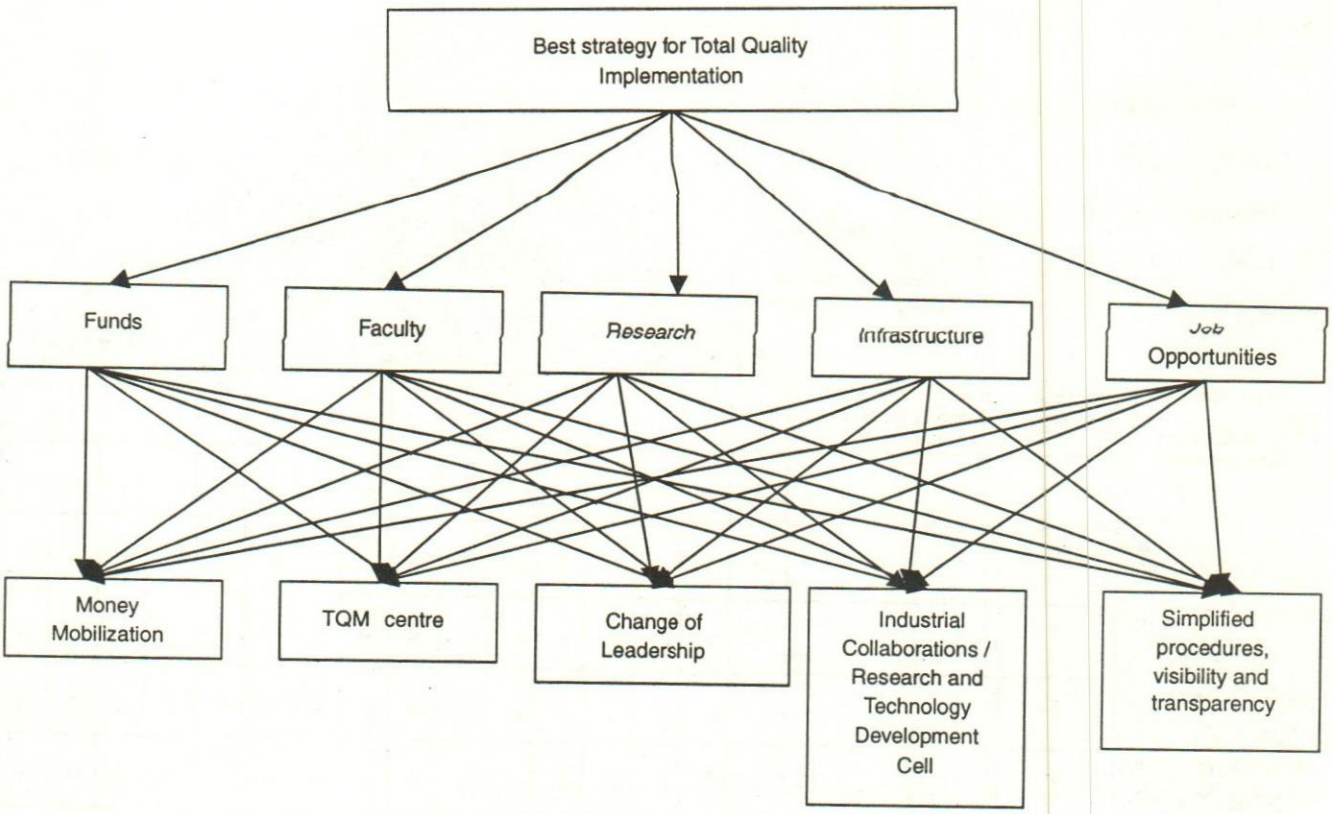


Fig. 4. AHP Framework

requirements are normalised by dividing each rating with the maximum available rating. The final ratings are tabulated in Table 1. Using the normalised ratings, the design requirements are prioritised as per their importance of design requirements as shown in Table. 2.

Table. 2: Ranking of Design Requirements

Sl. No.	The Design Requirements	The Normalised Refined Ratings	Ranks
1	Infrastructure	0.79439	5
2	Personality Development	0.54324	14
3	Services	0.47972	15
4	Job opportunities	0.77320	6
5	Motivated faculty	0.91222	2
6	Freedom	0.59350	13
7	Virtual Classrooms	0.64595	16
8	Funds	1.00000	1
9	Sponsored research	0.86789	3
10	Social obligations	0.59931	12
11	Achievements	0.72672	7
12	Attitude	0.71125	9
13	Standards	0.66874	10
14	Leadership	0.80124	4
15	Feedbacks	0.66473	11
16	Procedures	0.72133	8

The various alternatives or strategies that are devised are ranked using AHP framework, the results of which are listed in Table. 3.

Table. 3: Ranking of the Various Alternatives or Strategies

Strategy / Alternative	Rating	Rank
Money Mobilisation	0.3920	1
TQM centre	0.2586	2
Change of leadership	0.2043	3
Industrial Collaborations / Research and technology development cell	0.0711	5
Simplified procedures, visibility and transparency	0.0739	4

The calculations are made according to the following formula

Individual rating of the alternative A_i

$$= A_i = \sum_{i}^{n} Wc_i \; W(Ai)_{ci} \qquad ...(3)$$

where W_{ci} is the normalized weight of the design requirement i calculated from QFD analysis and $W(A_i)_{Ci}$ is the normalised eigen vector value for the alternative i under criterion i.

Individual rating of the alternative A_1 =

$$0.22853 \times 0.4180 + 0.20847 \times 0.4106 + 0.19834 \times 0.4805 + 0.18311 \times 0.1980 + 0.18154 \times 0.4370 = 0.3920$$

Conclusion

In the era of globalsation and liberalisation, it has been observed that multinational companies have started their operations in India. The manpower required in these firms must conform to the international standards, and training methods in educational institutions must have the capability to attract the students from all corners of the world. The existence of educational institutions largely depends on how effectively they address the challenges like diminishing fund position and improvement of quality of education and facilities. It is the right time for Indian educational institutions to realise the challenge ahead.

Toward the achievement of the above goals, this paper discusses the importance of application of TQM principles in the educational establishments so that they can adapt with the changing scenario. In addition, an attempt has been made to resolve the customer-product dilemma with regard to the students. A case study has been undertaken to demonstrate the applicability of QFD method in order to obtain vital information that will help policy formulation and infrastructure development during the planning stage. It must be remembered that one should not be content with a one time study, as there is always scope for improvement in any setup. Therefore, continuous improvement must be incorporated if an organisation is to succeed in today's competitive environment. QFD combined with AHP serves as a powerful tool, which is highly successful in eliciting the strengths, areas that require attention and strategies to be employed to achieve the results at the earliest. The various steps for perfection should be practised for overall improvement of the Education (Technical) setting. The method adopted here is quite general and not limited to the educational setting only. Rather, it can be applied to any service sector if the customer needs and the system design requirements are identified properly.

References

Arora, K.C. (1998), "TQM and ISO 14000", S. K. Kataria & Sons, New Delhi.

Brower, M. (1994), "The Paradigm Shifts required to Apply TQM and Teams in Higher Education", in Costin, H.(Ed.), Readings in Total Quality Management, Harcourt Brace, San Diego, CA, pp. 485-98.

Charles, E.R., Kramer, T.R., & Tian, R.G. (2003), "Return to Academic Standards: A Critique of Student Evaluations of Teaching Effectiveness", Quality Assurance in Education, Vol.11, No.1, pp. 37-46.

Cloutier, M. and Richards, J. (1994), "Examining Customer satisfaction in a Big School", Quality Progress, pp. 117-19, September.

Cullen, J., Joyce, J., Hassall, T. and Broadbent, M. (2003), "Quality in Higher Education: from Monitoring to Management", Quality Assurance in Education, Vol.11, No.1, pp. 5-14.

Ewell, P. T. (1993), "Total Quality and Academic Practice: The idea We've been Waiting for?", Change, Vol. 25, pp. 49-55.

Feigenbaum, A.V. (1991), "Total Quality Control", Mc Graw Hill Inc., Singapore, 3rd edition.

Marchese, T. (1991), "TQM reaches the Academy", American Association for Higher Education Bulletin, pp. 433-46.

Marchese, T. (1993), "TQM: A Time for Ideas", Change, Vol. 25, pp.10-13.

Pitman, G., Motwani, J., Kumar, A., & Cheng, C.H. (1996), "QFD Application in an Education Setting: A Pilot Field Study", International Journal of Quality and Reliability Management, Vol. 13, No. 4, pp. 99-108.

Prasad, B. (1995), "A Structural Methodology to Implement Judiciously the Right JIT Tactics", Production Planning & Control, Vol. 6, No. 6, pp. 564-577.

Rhodes, L.A. (1992), "On the Road to Quality", Education Leadership, Vol. 50, pp.76-80.

Schmidt, R. (2002), "A Students Initial Perception of Value when Selecting a College: An Application of Value Added", Quality Assurance in Education, Vol.10, No.1, pp. 37-39.

Rubach, J. (1994), "Fourth Annual Quality in Education Listing", Quality Progress, pp. 27, September. □

New ideas... are not born in a conforming environment.

– Roger von Oech

Realisation of Pragmatic Goals with TQM in Indian Organizations

Z. Rahman & J. Siddiqui

An effective model with the vision of sustainable competitive advantage for companies is Total Quality Management, which is a customer-centric set of management policies that deliver quality. This paper explains TQM philosophy and argues that a synergy between TQM and Information Systems can be quite fruitful in improving the quality of products and services offered to the end customer. Furthermore, if quality issues in the Indian industry are not addressed on time, competition might lead to elimination.

Z. Rahman is Assistant Professor, Department of Management Studies, Indian Institute of Technology, Roorkee. J. Siddiqui is Lecturer, Department of Computer Science, Aligarh Muslim University, Aligarh

Globalisation of market economies has led corporations in all sectors to concentrate on maintaining a sustainable competitive edge. However, sustainable competitive advantages are directly related to the upkeep of quality - both in terms of services as well productivity. An effective model of such a vision of success for companies is Total Quality Management (TQM) which is a customer-centric set of management policies that deliver quality. This is a cross-sectoral approach that takes care of the basic components of manufacturing and services and also the nitty-gritty details in accounts, finances, human capital and research and development.

As information systems have become an integral part of most organizations, they too fall within the scope of TQM. In fact it gains critical value in IS functions since data on microchips forms the baseline for many managerial decisions, business strategies, policies and mission of an organization. Considering the importance of Information Systems (IS) in almost all organizations, it is of paramount importance to provide top quality Information Systems structure and function of business and product value. This is possible for all organizations by adopting the principles, techniques and practices of TQM which requires them to meaningfully address managerial commitments, customer satisfaction, strengthening of employee base empowerment and evaluation and documentation of achievements. Further since all organizations have their specific SWOTs (strengths, weaknesses, opportunities, threats), it is for them to identify the areas for TQM before implementing it as an essential operational strategy.

Rationale

In the present study an attempt has been made to quantify the empirical aspects of TQM for the IS of organizations. It was reckoned by the perusal of past publications that organizations have had unqualified

success in pursuing quality management on account of multiple failures such as compound focus of programmes leading to dilution of results, assuming that action and result come in a package and lack of stepwise appraisal of schemes and achievements. Also it has been felt that IS professionals are still hesitant and apprehensive about adopting TQM in software engineering as a consequence of a general misunderstanding of its practices and principles (Zadrozny & Tumanic, 1992). A special emphasis on IS in this paper is aimed at clearing up these misunderstandings. We also wish to elaborate upon the ways in which IS can make use of TQM in India.

Since IT/IS are one of the fastest growing industries in India, which have been successful in establishing its reputable identity in the international arena, and the fruits it will yield are bound to grow manifold by all expected standards, adoption of quality programmes has been more than essential for survival in the IT industry. Given the long drawn experience of Indian industry with TQM in the field of IS this study has tried to evaluate the extent of their relationship in terms of awareness and utility. Further we also suggest that the results are quite general and they can be applied to the markets and industries of other countries as well, particularly those that have made a venture in the IS sector because information is a valuable asset for almost every organization. All organizations are making use of information and related systems to enhance quality and services to attain a firm grip over the market share.

TQM – concept and framework

TQM is a management philosophy that makes use of a particular set of principles, practices and techniques to expand business and profits. Because unequivocally, increased market share is a direct consequence of better quality since it provides a bypass to enhanced productivity by avoiding rework, rejects, waste, customer complaints and high cost (Deming, 1986). This can be achieved by emphasising the organization's relentless commitment to customer satisfaction and improvement of each and every process of production and service accruing from the data driven, problem-solving approaches of the top management and an accomplished employee base. Hence, TQM is not only the foundation for an organization's performance improvement but it is also the blue print for its perpetual upgrade and progress leading to a secure future. As it is a broad spectrum and all encompassing management philosophy, to define it in a few words would be nebulous hence we have tried to view TQM based on five basic pillars as outlined by Anderson et al (1994a), Dean and Bowen (1994), Waldman (1994).

Top management commitment works for all quality improvement programmes in a very effective manner since the vision of the leaders and policy makers at the top trickles down to the lowest strata of the employee base and henceforth it shows up in organizational productivity and delivery to the end user. It all begins with policy as a matter of rule and if a hardcore policy level decision incorporates quality improvement initiatives harvests are rich and easy to reap. The bearing of the top management group on TQM comes with compounded effect, seeing that this component of an organization is intricately involved in quality-level decisions and spends a great deal of time on formulating the measures to be taken for quality enhancement (Behling, 1997).

Customer centric advancements of processes are a prime requirement of quality programmes and the term "customer" delimits external (product users, suppliers and other components operating in the larger environment) as well as internal customers (fellow employees). The essential order in which these quality improvement programmes are delineated should be the identification of both types of customers in the very first place, determination of their specific needs, diversion of all activities towards their satisfaction and follow-up of the results through a feedback mechanism especially evolved for the purpose. The integral elements of such a design are to consider the customer as a potential partner, ultimate trendsetter and the recipient of all quality enhancement initiatives, evolving a yardstick for customer satisfaction and orientation, involving the customer in designing and assessing products and services and last but not least, building a long-lasting, trustworthy relationship between the organization and the customer (Lengnick-Hall, 1996).

Customer centric advancements of processes are a prime requirement of quality programmes.

Relentless development holds a special position in TQM since it instills an ambition in people so that they are not simply content with the existing success or past glories, but continuously strive to surpass them. It rests on the ideology that perfection is yet to be achieved and there is always room for more. However it must be clarified that TQM believes in gradual and incremental change rather than radical innovations, which are more likely to leave some aspect of process or product quality unaddressed. The key elements to development-oriented quality are an appetite for risk and a conviction to the dictum that 'nothing is permanent but change' in

the policy makers, customer focus by building two-way learning deluge between customers and organization, timely and honest self-appraisal, using mistakes and employee cynicism as a stepping stone and not obstacle, working within the organizational framework and finally setting goals and deadlines (Lynch & Werner, 1992).

TQM believes in gradual and incremental change rather than radical innovations, which are more likely to leave some aspect of process or product quality unaddressed.

Benchmarking is an important element of TQM since it involves structured problem-solving and identifying processes and finding opportunities for improvements and future developments. There are several specific tools and quality-adding techniques as mentioned by Hackman and Wageman (1995) & Zahedi (1995), such as quality function deployment, Pareto charts, statistical process control charts, cause and effect diagrams and affinity diagrams. Benchmarking however comes with the basic objective of minimizing variance or deviation of achieved success from the established quality standards. Again, reiterating the ideal of constant improvement once a particular process of quality orientation is standardised it is time to test it to an even higher and tighter standard of performance.

Strengthening the employee base is critical to TQM also as this constitutes the nature of the organization. The tenet under this ideology is that perpetual development can be achieved not only by enriching the employees with knowledge, learning and training but also by entrusting them with the power to take decisions. When employees are not bound by the dreary drudgery of simply living up to a set of laws and rules they can change their working mechanism at any stage of a process to concentrate on quality (Shrednick et al., 1992a). After minimizing the variance the management can rely on such employees to bring the quality of the end product under control and finally achieve the ultimate goal of any organization – to converge all its efforts to a concentric point where customer satisfaction is stationed (Anderson et al., 1994b).

TQM vis-a-vis IS

Practically no organization seems to be devoid of an information system in India although the extent of use and the advancement of the technology varies a great deal from company to company. Depending on finances and availability of infrastructure at least some use of computer-based information is mandatory for the management of all firms. A synergy between TQM and information technology can be quite fruitful in improving the quality of products and services offered to the end customer. Application of the five TQM principles applied to IS helps in decelerating wasteful expenditure in technology for the sake of technology (Ayers, 1993).

Top management initiatives work as a fountainhead to the progress of the institution and if it remains committed to functional change pursuing quality improvement its visionary approach and frontline leadership can streamline procedures to make information more accessible by reducing costs, eliminating bottle-necks and responding to the customer's needs without wasting any time (Reese, 1995). For this the top brass has to do something that is only its own reserved prerogative – to think of innovative ways of using IS/IT to develop certain processes by using its own creativity and understanding of the pros and cons of the organization. But before that the management has to abandon the stereotype mindset that IS is just a tool for performing several tasks faster and cheaper. At the same time they need to constantly reinforce customer focus, process development and recognize and celebrate achievements so that collective support is rewarded and encouraged.

The role of IT professionals comes unfurled in the second principle of TQM where development and rectification of work processes is stressed upon with the aim of meeting customer satisfaction and achieving sustainable qualitative advantage. IS can be used to measure, identify, monitor and design such product and service attributes that are of value to the customer. This begins with identifying the customers as a first step by the IS professionals, followed by defining their needs and expectations and enterprising to deliver to the required standards and finally by maximizing on customer involvement at all stages (Caroll & Swatman, 1997a; Stylianou et al., 1997).

Live and sound IS is critical to the continuous development of a company's worthiness for achieving sustainable, qualitative advantage. But software development also has its limitations as it can easily run in the uncontrolled realms of poorly managed functions (Dawson, 1994). Many times there are errors in the analyses stage of developing software. Continuous improvement is as important to traditional manufacturing as it is to software development. Dedication to systematic formal improvement pays for itself in quality and efficiency enhancement. This includes documenting, analysing and measuring all activities performed by IS

organization, standardisation and simplification of processes for limiting variability and being focused on the systematic process and not the end product or the individual performing the act (Kiely, 1993).

Settings of such innate parameters that evaluate the success of a project or a quality enhancement initiative give a good insight to the managers for decision-making and strategy development. Benchmarking is an effective tool to compare the company's achievements with its competitors and also for keeping at hand a structured problem solving mechanism (Buckler, 1994; Kiely, 1993). For example IS organizations make extensive use of benchmarking in maximizing data centre efficiency and cost control (Criner, 1994; Freedman, 1992). This includes documenting, analysing and measuring all activities performed by an IS organization. In a nutshell it means to evolve such structured yardsticks that measure achievements and make it easy to juxtapose the success with that of other close competitors. However the attention on the focal point of customer satisfaction through the improvement of the end product should never be lost to the endeavors of the individual, at any stage of this development.

The IS employee too needs empowerment by acquiring self-improvement skills, information and relevant resources. The most widespread methods for achieving this is by encouraging innovation and creativity in the employees, developing a culture of communication, encouragement and excellence. Recognition and reward for contribution to quality improvement of the organization also abets employees. The leadership style and personality remains a constant source of inspiration for the employees as it is emulated. In an IS organization they become of critical value and should start with a vision and clear goals, ensured management commitment, visible support, willingness to take risk, paying particular attention to managers and supervisors, involving staff at all stages of the project, downward and upward communication, staying tuned to the business, educating and training everyone and developing a reward system for achievements (Shrednick et al., 1992b).

But since dealing with human resources is a sensitive and tactical issue managers have to remember and be careful about the fact that most employees do not adapt readily to new things and resist to some extent, so they should not be forced to inculcate them (Prince, 1993). Only if an employee has it in him and enjoys the task will he do it, otherwise it is useless forcing him and wasting time and energy. But at the same time every employee is gifted with some attribute in work or personality of which the organization can make use. Assigning tasks in such a way that even weaknesses in a person can be exploited for the organization's interest rests on the manager's knack of knowing a task and his employee well. Finally only teams can accrue the magic of TQM so group living and productive liaisons in a company's employee base should always be looked up to.

Benefits of TQM for IS are many if the above principles are successfully implemented and in the long run these may also be potentially significant ones (Carroll & Swatman, 1997b; Pearson et al 1995a). These include improvements in quality and productivity e.g. higher quality products and services, low cost and reduced time; improvements for staff and management e.g. better utilisation of human resources & management control, high morale, teamwork and job satisfaction; improved relations with customers e.g. increased customer focus, customer satisfaction and awareness of the importance of service, increased flexibility in meeting customer demands; and strategic benefits such as increased alignment with corporate culture and organizational objectives and better targeting of business values.

Objectives

To defend the given hypothesis based on the philosophy of TQM and its applicability to IS the specific objectives of this study are to explore the following areas in the sector of IS functions of India:

1. The awareness usage and length of experience of TQM in IS
2. The extent of top management support for TQM in IS
3. The extent of benefits realized by TQM
4. The extent to which the TQM principles are applied to IS
5. Relationship between IS-TQM realized benefits and top management support
6. Relationship between the IS-TQM realised benefits and TQM principles implemented.

Study Area

During the last decade as India opened itself to the liberal market economy, after several decades of stiff regulations in business strategy, the manufacturing and service industries have made a significant contribution to the phenomenal economic growth made by the nation in the global market. However it has been realised that the national market has suffered deterioration in some areas due to a lack of competitive sustainability. For example the influx of foreign goods – Chinese locks for instance, has caused a serious blow to the native lock industry. Similarly in many other sectors the Indian

products and services are losing out to competition with imported stuff, as they are either more cost effective or better in quality. Furthermore as the Indian customer becomes more and more brand savvy – largely owing to the media exposure, quality consciousness is bound to increase and if quality issues in the Indian industry are not addressed in time, competition might result in elimination.

This new wave of quality awareness has had an impact on business operations in India forcing the industry to take a paradigm towards being high-quality producers rather low-cost producers. As a result lately Indian firms have increased investment on quality management imperatives rather cost-cutting alone as they have realised that competition solely on the basis of cost is extremely difficult. Now that some firms have awakened to the need of quality improvement and adopted TQM as the remedial measure, it is time to evaluate the success of their achievements and quantify the goals realised by them in practicality.

Methodology

Data Collection

Similar studies conducted in various sectors abroad (Pearson et al., 1995b; Ahire et al., 1996; Cheon & Stylianou, 2001) were consulted and due modifications were done to suit the Indian firms and Information Systems departments to design a questionnaire that could derive information and opinions from organizations. Data collection was done by mail survey questionnaires. The items were written in the form of statements to which the respondents responded using a seven-point Likert-type scale (ranging from strongly disagree to agree).

The data set was intended to represent a large variance in their annual turnovers, worth of assets, IS budgets and the segment of the industry to which they catered. Addressed to the top executive incharge of the IS department the survey questionnaire was mailed to 300 Indian companies assumed to be making use of TQM in their Information Systems department. The list was procured from the BT-500 list of top Indian companies published by *Business Today.* A follow up questionnaire was mailed to those who did not respond up to eight weeks and another follow up was sent after a no-reply for twelve weeks.

Out of the total questionnaires dispatched only 134 came back with responses and it was found that 14 of them were rendered unreliable due to ambiguous answers. Finally 120 responses (40%) were included for analysis and drawing inferences. The questionnaire recipients were selected from a wide array of business areas and the firms belonged to different classes such as insurance, banking, software, manufacturers etc. The received bulk of responses also represented this spectrum chosen for the study.

Data Analysis

Usable responses were sorted out from the bulk of responses received. Non-response bias was checked by comparing the answers provided by the first respondents with those provided by respondents following the second and third mailing (Fowler, 1998). This could be done safely because analysis indicated that there is no significant difference at the level of $P = >0.05$ among these three groups with respect to their total sales, number of employees, IS budgets and number of IS employees. As an added advantage this lack of non-response bias implies that the results obtained from this study sample can be implied to a larger set of population too.

Results

Comprehension level of TQM amongst IS managers

Table 1 illustrates that all the 120 managers who responded to the survey had heard of TQM. However their levels of familiarity and awareness about the process varied from a range of 3.3% (very little) to 37.5% (somewhat). This indicates that a larger portion of the group had quite a fair idea of the TQM principles. It further reveals that their perception about the impact of TQM on IS was also on the positive side i.e. almost two-thirds of the group believed that TQM contributed positively towards IS improvement.

Table 1: Comprehension level of TQM amongst IS managers

Comprehension level		Frequency		Per cent	
Heard of TQM	Yes	120	120	100	100
	No	0		0	
Familiarity with TQM Principles	Very much	15	120	12.5	100
	Much	30		25	
	Somewhat	45		37.5	
	A Little	26		21.66	
	Very Little	64		3.33	
Concept of Effect of TQM on IS	Very Much	14	120	11.6	100
	Much	66		55	
	Moderate	32		26.6	
	A Little	8		6.66	
	Very Little	0		0	

Length of TQM in IS Experience

Responses depict (See Table 2) that all the 120 respondent firms (100%), were making use of TQM in IS. A miniscule amount (3%) of them, have a long drawn experience (more than five years) of TQM in IS. The largest percentage (43%) is of those firms which have been exploiting TQM for more than a year, but less than three years. About 21% are senior to this group by one or two years and 32.5% are yet to mature to a year's experience.

TQM Benefits for IS

As already mentioned in the methodology respondents were asked to rate the TQM benefits for IS on a seven point Likert-type scale ranging from disagree to strongly disagree. Most respondents felt that the most desirable benefit of TQM for IS, is increased quality of services and products followed by a greater productivity of IS professionals.

Table 2: Length of TQM in IS experience

Length (year)	Frequency	Per cent
Less than 1	39	32.5
1 to 3	52	43.33
3 to 5	25	20.83
Above 5	4	3.33
Total	**120**	**100**

Table 3: Benefits of TQM for IS

TQM Benefits	Mean	Standard Deviation
Cost cutting on maintenance of applications	4.6333	1.3014
Increased IS management control	5.2175	1.0041
Superior quality of services	5.3245	1.1147
Greater customer satisfaction	5.2126	1.1834
Enhanced IS professional productivity	5.0999	1.0738
Slashed time consumption on production	4.2133	1.1873
Improved quality of products delivered	5.2526	0.9768
Optimization of human resource use	5.0106	1.1867
Flexibility in reaching out to customer	5.1349	1.2013

Implemented TQM Principles

The questionnaire contained a Likert-type seven point scale ranging from disagree to strongly agree regarding the implementation of the five principles of TQM in IS. The respondents measured the success achieved in this implementation on the scale. It was found after analysing the opinions that the most effectively used TQM principles were those of customer-centric advancements and employee enrichment by strengthening the employee base (See Table 4). However, when implemented to IS other TQM principles also did fairly well.

Table 4: Degree of implementation success with TQM principles in IS

Implemented TQM Principles	Mean	Standard Deviation
Conviction of top management	4.8563	1.1432
Customer-centric advancements	5.3675	1.1046
Relentless improvement	4.8823	1.2768
Strengthening of employee base	5.2363	1.1134
Benchmarking	4.7342	1.3391

Relationship Between Top Management and TQM Benefits

Of the 120 responses received 58% (n = 70) felt that TQM for IS receives strong support from the top management in their firm and 42% (n = 50) in their firms TQM for IS receives somewhat less or very little support from the top management. Relationship analysis was done by subdividing the respondents opinions into two categories – high for much and very much; and low for little and very little. Subjecting to the test of goodness of fit revealed that there is a significant difference between benefits accrued from TQM through strong management support and those of less management support (See p value in table 5). Hence it can be concluded that top management commitment to TQM is a decisive factor of TQM benefits for IS organizations.

Table 5: Relationship of Top Management Support and TQM Benefits

Variable	Top Management Support	Mean	T-Value	p-value
TQM Benefits	High (n = 70)	5.6234		
	Low (n = 50)	4.1867	3.186	.0023

Implementation of TQM Principles and Benefits Realised

The simple regression analysis was performed to test the significance of the relationship of each TQM

principle implemented and TQM benefits realised. The key motive of each test was to see if the simple linear equation is significant or the observed frequencies are just a matter of chance. Analysis revealed that each equation was significant at 0.05 level with R^2 ranging from 0.30 to 0.35.

The results of all possible regression analysis shows that two independent variables provide the key impressions for TQM benefits of IS organizations – these are customer-centric advancements and support of top management. Therefore from table 6 we may conclude that the successful implementation of TQM principles and realisation of benefits relies on these two important factors of critical value. Hence the null hypothesis that the frequencies of different observations for TQM principle implementation are chance observations and there is no working mechanism behind them is, rejected.

Table 6: Relationship Between Implemented TQM Principles and TQM Benefits

TQM Principles Implemented	TQM Benefits Realised		
	T for H_0: Parameter=0	P-value	R^2
Conviction of top management	4.476	.0001	0.3527
Customer-centric advancements	4.378	.0002	0.3271
Relentless improvement	3.324	.0005	0.3043
Strengthening of employee base	4.276	.0002	0.3297
Benchmarking	2.547	.0328	0.1189

Discussion

Before we discuss the results obtained by the research methodology adopted we must also clarify the limitations of the data collection and its analysis. The results have been promulgated on the basis of opinions expressed by one individual of a firm because in one organization only one questionnaire was mailed. Hence any difference of opinion between individuals of the same company has not found scope of representation, as multiple opinions from a firm have not been entertained. Maybe a study with such design could give wider representation to the management of the company. For any questionnaire-based survey it is impossible to completely eliminate the bias from respondents while filling the spaces because data is opinion-based and not numerical based. Another limitation of this study is that we assumed at the beginning that the respondents have a fair understanding of TQM philosophies and hence we did not include any statements that test the comprehension level of the respondents about TQM. However these lacunae in the study leave future ground for explorations and research on the subject.

On the basis of the study results we might state that TQM for IS organizations is catching up fast amongst Indian organizations because 100% respondents had heard of TQM. Also the greater portion of the sample (more than two-thirds) was familiar with TQM and were convinced that it has a good impact for IS organizations. Further detailed quest reveals that organizations in India are adopting TQM readily as most of them have several years of experience with TQM for IS. We may argue based on this finding that in future more and more companies will subscribe to the philosophies of TQM. This readiness may be attributed to the benefits of TQM realised by IS functions, the most common ones being greater customer satisfaction, increased productivity of IS personnel and enhanced quality of services and products. However, the other benefits such as cost and time cutting on production and optimization of human resources too are rated well as TQM benefits. This shows TQM is taken in a good light for the allover performance of the company. Amongst all the TQM principles described earlier the best implementation success was received in the principles of customer-centric advancements and employee enrichment by strengthening the employee base. This shows that TQM has the capability to entice the primary as well as the secondary customer. In-depth relationship analysis of TQM implementation and TQM benefits depicts that the most important factor on which TQM implementation benefits rely is the top management support. Most of the respondents felt the degree of success achieved in implementing TQM has a strong relationship to the commitment and support provided by the top management, as it is the fountainhead for all key policies of the firm.

Finally it was concluded that the key influencers of TQM benefits were customer-centric advancements and top management's support. Therefore, the successful implementation of TQM depends on these two key factors. Earlier also many authors have realized the importance of the top management support for TQM and recommended the following practices to be embraced for good commitment to TQM (Cortada 1995): a) setting strategic visions and conveying them to employees, b) preserving high standards of measurable quality c) modeling the way to customer end user focus, c) fostering a world of continuous improvement and d) empowering the employee base by encouraging teaming, initiatives and individual accomplishments.

Similarly, to assure customer-centric advancements to facilitate better TQM implementation steps have been

suggested. Pearson et al (1996 - 1997) has outlined them as a) identify the real IS customer; b) understand their expectations and c) commit to the flagship processes critical to the success in meeting these expectations.

Since this study was conducted in India when almost the entire market had adopted itself to globalisation it will not be out of place to suggest that the research findings also have global applicability apart from being of use to the academics and business environment of India. If not to the well-advanced west at least for neighbouring countries such as Pakistan, Bangladesh, Nepal, Maldives, Sri Lanka, Bhutan in the SAFTA (South Asian Free Trade Association) these findings are well applicable because they have a similar cultural and traditional milieu. In an unexaggerated form the applicability may even radiate to the not so far off Middle East and Polynesia.

When the study was compared with other published work similarities were discovered in the results. For example Howard and Foster (1999), Hua et al (2000), Rao and Raghunathan (1997) and Sohal et al (1998) also support the importance of top management commitment for TQM implementation. Our findings are also in agreement with the publication of Pearson et al (1995c) with regard to the extent of TQM awareness amongst IS professionals. Dahlgaard et al (1998), however, imply that a significant gap remains between the success with TQM for IS in the west and the east. But there too additional emphasis on top management commitment and employee strengthening by on the job training and education is stressed. If the gap is only in the extent of success and adaptability and not regarding a basic philosophy or trend then it is only a matter of time when business traditions in the east too will incorporate TQM as an integral element as in the west.

However to reduce the limitations mentioned above further detailed research is recommended. Meanwhile, customer-centric advancements and top management commitment are highlighted as the key variables that influence TQM, which accrues benefits such as customer satisfaction and cost cutting for IS organizations.

References

Anderson, J., Rungtusanatham, M., & Schroeder, R. (1994), "A theory of quality management underlying the Deming management method," Academy of Management Review, July, 19(3), 472-509.

Ayers, J.B. (1993), "Total Quality Management and Information Technology: Partners for Profit," Information Strategy. The Executive Journal, Spring, 9(3), 26-31.

Buckler, G. (1994), "Do you measure up?," I.T. Magazine, January, 26(1), 14-17.

Cheon, M.J. & Stylianou, A.C. (2001), "Total Quality Management for Information Systems: An Empirical Investigation," Journal of Global Information Technology Management, 4(4), 32-5.

Cortada, J.W. (1995), "TQM for Information Systems Management", New York, McGraw-Hill, Inc..

Carroll, J., & Swatman, P. (1997), "Total quality management for information systems: The Australian experience," Proceedings of 8th Australian Conference on Information Systems.

Criner, J.C. (1994), "Benchmarking data processing installation," Capacity management review, March, 22(3), 1-6.

Dalghard, J.J., Kristensen, K., Kanji, G.K., Juhl, H.J., & Sohal-Sohal, A.S. (1998), "Assessing manufacturing/quality culture and practices in Asian companies," International Journal of Quality & Reliability Management, 15(8/9), 920-930.

Dawson, S.P. (1994), "Continuous improvement in action: Applying quality principles to software," Information Systems Management, 11(1), 31-39.

Dean, J.W. & Bowen, D.E. (1994), "Management theory and total quality: Improving research and practice through theory development," Academy of Management Review, July, 19(3), 392-418.

Deming, W.E. (1986), "Out of the crisis", Cambridge: MIT Press.

Freedman, D. (1992), "Those Who Can, Teach," CIO, September 1, 5(17), 46-51.

Hackman, J.R. & Wageman, R. (1995), "Total quality management: Empirical, conceptual, and practical issues," Administrative Science Quarterly, June, 309-342.

Howard, L.W., & Foster, S.T. (1999), "The influence of human resource practices on empowerment and employee perceptions of management commitment to quality," Journal of Quality Management, 4(1), 5-32.

Hua, H., Chin, K.S., & Xu, Y. (2000), "An empirical study on quality management practices in Shanghai manufacturing industries,"Total Quality Management, 11(8), 1111-1112.

Kiely, T. (1993), "IS quality: Improvement starts at home," CIO, April 15, 6(10), 40-46.

Kiely, T. (1993), "IS quality: Getting to know the neighborhood," CIO, April 15, 6(10), 48-50.

Lengnick-Hall, C.A. (1996), "Customer contributions to quality: A different view of the customer-oriented firm," Academy of Management Review, July, 21(3), 791-824.

Lynch, R.F. & Werner, T.J. (1992), "Continuous Improvement", Atlanta, Ga: Qual Team Inc.

Pearson, J.M., McCahon, C.S., & Hightower, R.T. (1995), "Total Quality Management: Are information system mangers ready?," Information & Management, 29, 252-263.

Pearson, J.M., McCahon, C.S., & Hightower, R.T. (1996-1997), "A framework for the introduction of total quality management into the IS department," Journal of Computer Information Systems, Winter, 37(2), 21-26.

Prince, E.T. (1993), "Human factors in quality assurance," Management, Summer, 10(3), 78-80.

Rao, S.S., & Ragunathan, T.S. (1997), "A comparative study of quality practices and results in India, China and Mexico," Journal of Quality Management, June, 2(2), 235-249.

Reese, S. (1995), "Sharpening your competitive edge with information systems" Industrial Management, January/February, 37(1), 13.

Shrednick, R.H. (1992), "The Quality Quagmire," CIO, November 1, 6(3), 28-31.

Sohal, A.S. (1998), "Assessing manufacturing/quality culture and practices in Asian companies," International Journal of Quality & Reliability Management, 15(8/9), 920-930.

Stylianou, A.C., Kumar, R.L., and Khouja, M.J., (1997), "Total quality management-based systems development process," DATABASE for Advances in Information Systems, 28:59-71.

Waldman, D.A. (1994), "The contributions of total quality management to a theory of work performance," Academy of Management Review, July, 19(3), 510-536.

Zadrozny, M.A. & Tumanic, R.E. (1992), "Zero-Defects Software: The Total Quality Management Approach to Software Engineering," Chief Information Officer Journal, Spring, 4(4), 10-16.

Zahedi, F. (1995), "Quality Information Systems", Danvers, MA: Boys & Fraser Publishing Company.

□

Honest disagreement is often a good sign of progress.

– Mohandas K. Gandhi

Feature

Customer Requirements and Constructs in Engineering & Management Institutions

Sangeeta Sahney, D. K. Banwet & S. Karunes

The education system and more so the higher education system finds itself in a market-oriented environment, with internal and external customers, wherein, 'delighting the customer', is the rule for survival in the long run. It is important not only to identify the numerous and varied customers of the educational system, but also to identify their requirements and satisfy them. Based on a theoretical foundation, this paper is an empirical study conducted on select higher educational institutions to identify various customer requirements.

Sangeeta Sahney is Lecturer in the Department of Management Studies, Indian Institute of Technology, Roorkee, D.K. Banwet is Group Chair (Operations) at IIT, New Delhi and S. Karunes is a retired Associate Professor, IIT, New Delhi.

The Indian educational system, as elsewhere in the world, finds itself operating amidst tremendous pressures from both internal as well as external forces in its environment. The higher educational institutions and in particular institutions imparting professional education to its students, are faced with demands for greater responsiveness and accountability. Educational institutions are numerous and varied and operate in a market-oriented environment. This has manifested itself in the form of competition amongst such educational institutions, to provide for services better than their counterparts and gain a good ranking amongst the accreditation agencies. The answer to such pressures lies in 'delighting the customer', which is the rule for survival in the long run. 'Delighting the customer' is the core message of Total Quality Management (TQM) and hence, there is a need to identify and apply the relevant concepts of TQM. It is important not only to identify the numerous and varied customers of the educational system, but also to identify their requirements and satisfy them.

This paper presents the results of an empirical study conducted on select higher educational institutions to identify the various customer requirements.

Theoretical background

Customers of the Educational System

A customer is anyone being served. Customers may be both internal and external, depending on whether they are located within or outside the organization. Quality starts with the customers and is defined by the customers. So one must be able to identify one's customers, to be able to meet their needs and satisfy them. In education, the criteria for quality, and therefore the customer requirements, involves a much greater number of interested parties - students, staff, faculty, industry, parents and the society. It is essential that cus-

tomers be identified and processes be established in order to determine specific needs and maintain customer-oriented service (Lembcke, 1994; Spanbauer, 1995a).

Winch (1996) refers to the ambiguity in defining who the customers of the system are. Some of the reasons follow. First, it is not obvious that the clients of education are the consumers of education, with the client being often in a poor position to make a judgement of the quality of what he is receiving. Second, there are various interest groups. Third, some of these interest groups are financial contributors to the maintenance of the educational system. Fourth, while in a classical economic marketplace, the customer has the exit option, here the customer has a much smaller degree of autonomy.

A customer is anyone to whom a product or service is provided (West-Burnham, 1992). Downey, Frase and Peters (1994), say that the primary customer in an education system is the student, who is both an internal and an external customer. While in the system, the student is an internal customer, participating in the learning process; he becomes an external customer when he leaves the system. He then becomes the ultimate external customer, functioning effectively in the society. The external customers include higher educational institutions, business, industry and society. All employees are internal customers of one another - each is a supplier and a customer to someone else, either within or outside the organization.

Madu et al.(1994), refer to the different customers and classify them as input customers, transformation customers and output customers. While the parents and students are included as input customers, the faculty is the transformation customer and the corporations and the society are the output customers.

Spanbauer (1995b), refers to the students as the primary customers, with the customer-relationship being somewhat different - the student may not know what they need to learn and it does not necessarily mean that they must be given whatever they request. It is the faculty that can determine the needs of the students and balance those with the needs of other customers, viz., the employer and other educators who may later provide advanced instruction. The instructor is a customer or supplier for internal processes too. The administrative staff / support staff, are suppliers of services to the faculty and staff, and so the faculty becomes the customer of the administrative / support staff. Spanbauer thus, remarks that customers are of two types - external (students, employers, the community at large, taxpayers, other educators from different institutions) and internal (other instructors, service department staff).

Sirvanci (1996), states that while it is generally assumed that students are the customers of the institutions they attend, it is actually more complicated than that. Infact, he remarks that there is no single role that can be attached to students in higher education. In general, 'students may take on four different roles within the institution' - they are the product in process; the internal customers for many campus facilities; the labourers of the learning process; and the internal customers for delivery of the course material.

Kanji et al. (1999), classify the customers of higher education into primary and secondary groups on the basis of their locations i.e., whether internal or external, and the frequency of interactions the institution has with them. While the educator (as employee), is defined as the primary internal customer, the student (as educational partner), is the secondary internal customer. Similarly, the student is also the primary external customer and the government, industry and parents are the secondary external customers.

Students are generally accepted as the primary customers (Brower, 1991; Hitmann, 1993; Sallis, 1993a), other potential customers, like parents, employers, government and society, should also be considered (Owlia and Aspinwall, 1996 a). Further, while students are the prime customers, they are also their raw material, suppliers, co-processors and products (Harris, 1992).

Among the groups within higher education (faculty, students and administration), there seems to be little agreement as to who are the true customers. The recently developed Malcolm Baldridge National Quality Award Education pilot criteria, which were adapted from the Baldridge Award Criteria for business, avoid using the term "customer". In addition, the 'customer focus' and 'satisfaction' category has been changed to 'student focus' and 'student and stakeholder satisfaction'. The use of 'student' and 'stakeholder' in place of 'customer' may communicate to educational institutions that students are the only customers and lead them to view students' satisfaction as their only ultimate objective, but this is misleading. Infact, it has been pointed out that there are some fundamental differences between students and customers including freedom of choice, responsibility for paying the price and requirements to prove merit and eligibility.

The question of whether the student is the customer depends on which aspect of the education process is being investigated. Hau (1991), when studying quality improvement in teaching concluded that students are

the primary customers for the delivery of the course material, but not for the content of the course.

Sallis (1993b), explains that education is a service - value added to learners, where the learner is the primary external customer or client; parents and employers are secondary external customers; the labour / job market, government and society are the tertiary external customers; and, teachers, administrators and support staff are regarded as external customers.

Tuttle (1994), remarks that there are many customers of higher education, and the definition of a customer depends upon the 'businesses' that are being discussed, viz., research, service, or teaching and learning.

Some researchers have been skeptical about the students being referred to as the prime customers of higher education (Marchese, 1991; Rhodes, 1992). Marchese (1991), points to the importance in meeting / exceeding the expectations of internal customers by each office. Infact, Rhodes (1992), attributes the 'student-centredness', to be the cause of 'some of education's most serious management problems.' However, Ewell (1993), views the students as customers, only when they are recipients of services and not when they are recipients of education, when 'he is the raw material of a specified process of production'. Pitman et al., (1995), refer to students both as a customer and a product.

Michael et al.,(1997), refers to the dilemma in referring to the students as customers. According to them, the faculty raise objections when it is said that the customer (here the student) is always right, because they believe that giving the students what they want will not necessarily lead to higher quality education, with students concerned with short-term satisfaction (making the grade) as opposed to the long-term gain (actual learning and growing).

The student is a part of the input amongst others. He is also a customer but there are other elements in the form of teachers, administrators, parents, employers, government and the society. The needs and views of the various customer groups, whether they are internal or external, may not always coincide and the best method of resolving different interests is to recognize their existence and to look for issues that unite the different parties.

Customer Requirements

Accepting the large number of stakeholders that an educational system has, this study confines itself to the administrative staff and the faculty as internal customers of the system and the students and the industry as the external customers of education. Each of these groups has diverse requirements / expectations that need to be prioritised and reconciled. An attempt has been made to conceptualise and operationalise the various customer requirements.

Based on the literature review, and with particular emphasis on the various models and performance indicators in education, the variables and the items for the study were conceptualised. The customer requirements refer to the expectations of the various groups of customers (administrative staff, faculty, students and industry), from the educational system. The various items along with their sources in literature are tabulated (See Table 1).

Empirical Study

I. Objectives of the Study

The study has been conducted with the following objective:

To identify the various requirements of the numerous customers of the educational system.

II. Methodology

(A) Type of Study Undertaken: The focus of the study was on identifying the requirements of the numerous customers of the educational system. So, the study is exploratory / formulative and diagnostic in nature with an emphasis on discovery of insights and ideas.

(B) Scope of the Study: The study was confined to select engineering and management institutions imparting graduate and post-graduate professional degrees / diplomas. The sample included both, the internal as well as external customers of the education system - the administrative staff and the faculty as internal customers and the students and the industry as external customers. An attempt was made to obtain cross-sectional data.

(C) Research site: The research site was confined to engineering institutions and management institutions in and around Delhi.

(D) Sampling technique: An attempt was made to target education institutions offering professional degrees / diplomas - either management or engineering.

The study used probability as well as non-probability sampling for selecting the respondents. While selecting the institutions, non-probabilistic convenience and judgmental sampling technique was used. How-

Table 1: Requirements of various groups of Customers

S. No	Items	Questionnaire				Source
		A	F	S	I	
1	Appropriate physical facilities / infrastructure	√	√	√	√	Harvey et al. (1992), Ashworth & Harvey (1994), Horne & Pierce (1996), Owlia and Aspinwall (1998)
2	Adequate facilities and equipment	√	√	√	√	Redfern (1980), Ashworth and Harvey (1994), Horne and Pierce (1996), Owlia and Aspinwall (1998)
3	Visually appealing environment			√	√	Owlia and Aspinwall (1998)
4	Salary	√	√			Raisbeck (1994)
5	Allowances and benefits	√	√			Developed by Self
6	Office management	√				Adapted from Owlia and Aspinwall (1998)
7	Knowledge of official procedures	√				Adapted from Owlia and Aspinwall (1998)
8	Teaching assistants / project / secretarial help		√			Developed by Self
9	Faculty's expertise			√	√	Nadeau (1993), Owlia and Aspinwall (1998)
10	Faculty's teaching ability and skills			√		Horne and Pierce(1996)
11	Sufficient faculty / support staff			√	√	Owlia and Aspinwall (1998)
12	Instructional / educational leadership			√		Scheerens (1992), Nadeau (1993), Spanbauer (1995), Lozier and Teeter (1996), Tang and Zairi (1998)
13	Effective classroom management		√	√		Krajewski et al. (1983), Trethowan (1987), Bollington et al. (1990), Horne and Pierce (1996)
14	Proper classroom procedures		√	√		Adapted from Krajewski et al. (1983)
15	Orientation towards achievement			√		Scheerens and Bosker (1997)
16	Opportunities for campus training and placement			√		Harvey and Knight (1996)
17	Healthy competitive environment			√		Scheerens (1989 1992)
18	Effective problem solving	√	√	√		Owlia and Aspinwall (1998)
19	Cooperation and collegiality			√		Harvey and Green (1994)
20	Information sharing and exchange	√	√	√		Developed by Self
21	Interpersonal relations	√	√	√		Nadeau (1993)
22	Supportive superiors	√	√			Developed by Self
23	Rapport with students		√			Redfern (1980)
24	Consensus / cohesion in management affairs	√	√			Scheerens and Bosker (1997)
25	Autonomy of work / freedom	√	√			Marchington (1992)
26	Opportunity and control for curriculum development / preparation		√			Developed by Self
27	In-service training and development	√	√			The Conference Board (1993)
28	Continuous personal growth	√	√			Lewis and Smith (1994)
29	Reward structure / recognition for work done					Trethowan (1987)
30	Recognition for work carried	√	√	√		Trethowan (1987)
31	Willingness to help			√	√	Owlia and Aspinwall (1998)
32	Politeness and courtesy	√	√	√	√	Raisbeck (1994)
33	Orderly environment conducive to teaching and learning	√	√	√		Edmonds (1979)
34	Learn to apply			√		Developed by Self
35	Appropriate classroom hours			√		Tomlinson (1980)
36	Maximum learning time			√		Scheerens (1989)
37	Clarity of course objectives			√		Developed by Self
38	Adherence to course objectives			√		Developed by Self
39	Relevance of curriculum to future needs			√	√	Owlia and Aspinwall (1998)

(Table 1 contd.)

Table 1: Requirements of various groups of customers (Contd.)

S. No	Items	Questionnaire				Source
		A	F	S	I	
40	Ease of contact / access to teachers and administrative staff			√		Raisbeck (1994)
41	Ease of access to the institution				√	Owlia and Aspinwall (1998)
42	Responsiveness			√	√	Parasuraman et al.,(1985)
43	Flexibility of knowledge being cross disciplinary			√	√	Owlia and Aspinwall (1998)
44	Individualised / personalised attention	√	√	√	√	Horne and Pierce (1996)
45	Proper monitoring systems and evaluation procedures	√	√	√		Nadeau (1993)
46	Timely feedback on performance			√		Rutter et al.
47	Record keeping on performance			√		Krajewski et al. (1983)
48	Clearly specified values and aims	√	√	√		Developed by Self
49	Consistency of practice	√	√	√		Developed by Self
50	Clearly specified policies / guidelines	√	√	√		Developed by Self
51	Fairly and firmly enforced rules and regulations	√	√	√		Scheerens and Bosker (1997)
52	Security of job	√	√			Lewis and Smith (1994)
53	Trustworthiness and credibility				√	Owlia and Aspinwall (1998)
54	Dependability			√		Developed by Self
55	Consistency in terms of similarly qualified people				√	Owlia and Aspinwall (1998)

A - Administrative / Support Staff, **F** - Faculty, **S** - Students, **I** - Industry

Table 1: Requirements of various groups of customers (Contd.)

S. No	Items	Questionnaire				Source
		A	F	S	I	
	Requirements from the students					
1	Core / basic knowledge				√	Edmonds (1979), Ashworth and Harvey (1994), Harvey and Knight (1996)
2	Specialised / advanced knowledge				√	Harvey and Green (1994), Kearney (1998)
3	Analytical ability				√	Harvey et al. (1992), Harvey and Green (1994), Suganthi et al. (1998)
4	Computer data acquisition / analysis / programming				√	Owlia and Aspinwall (1996), Kearney (1998)
5	Decision-making ability				√	Harvey and Green (1994)
6	Communication skills				√	Nadeau (1993), Harvey et al. (1993), Harvey and Green (1994), Harvey and Knight (1996), Owlia and Aspinwall (1998), Kearney (1998)
7	Interpersonal/relationship building skills				√	Ashworth and Harvey (1994), Harvey and Green (1996), Suganthi et al. (1998), Kearney (1998)
8	Ability to learn and apply knowledge				√	Kearney (1998)
9	Teamwork				√	Marchington (1992), Harvey and Green (1994), Owlia and Aspinwall (1998), Kearney (1998)
10	Risk-taking ability				V	Kearney (1998)
11	Desire to continue learning				√	Harvey and Green (1994), Kearney (1998)
12	Ethics and morality				√	Developed by Self

A - Administrative / Support Staff, F - Faculty, S - Students, I - Industry

ever, within such institutions, the respondents were selected by stratified random sampling.

(E) Method of Data Collection and Instrument Used for the Study: After a literature review, certain variables / constructs / dimensions were identified, that were adapted and incorporated in the questionnaires that were distributed to the respondents.

(F) Sample size: A total of 43, 52, 85 and 45 ques-

tionnaires were distributed to the administrative / support staff, faculty, students and industry respectively. However, a total of 35 each for administrative / support staff and faculty, 55 for students and 30 for industry were finally found to be complete and valid for analysis.

(G) Data analysis: Arising from the literature review, certain items were identified. These items have already been referred to (See Table 1). These items were adapted and incorporated in the questionnaires that were distributed to the respondents. For conducting the study, four different sets of questionnaires were developed, one each for the four categories of customers.

The questionnaires based on literature review were tested to examine the validity and reliability of the scale and enable a quantitative and statistically proven identification of requirements of customers. The different sets of questionnaires were distributed to the administrative staff, faculty, students and some companies from the industry. After the responses were collected, the data was analysed separately. Qualitative validity was tested through the theoretical study as well as through expert comments. The test for quantitative validity was done through an Exploratory Factor analysis. The Principal component method was used. With Eigen values above 1 and the maximum iterations for convergence as 100, the Varimax Rotation was applied and Rotated factor loadings examined. Factor loadings above α values of .50 were considered. Internal consistency was examined through a reliability analysis. The Cronbach's α model, inter-item correlation and covariances was used and alpha values over .50 were considered.

First Questionnaire: Administrative / support staff

Based on a literature review, 24 items were identified that were incorporated in a questionnaire, (Table 1). The test for validity through Rotated Component Matrix identified 14 items out of a total of 24 items. These got grouped under four factors / constructs for customer requirements and these factors were termed as tangibles, attitude, delivery and reliability.

1. Tangibles - Proper physical facilities/ Infrastructure, salary, allowances and benefits.
2. Attitude - Effective problem solving / complaint handling, information sharing and exchange, cordial interpersonal relations, supportive superiors, proper monitoring systems and evaluation procedures.
3. Delivery - Autonomy of work / freedom, in-service training and development, individualised / personalised attention.
4. Reliability - Consistency of practice, clearly specified policies / guidelines, fairly and firmly enforced rules and regulations.

The Cronbach's α values for the different factors of customer requirements ranged from .5637 to .8344 indicating that the scale was internally consistent and reliable (Cronbach,1951a; Nunnally, 1978a). The variables, with their respective items obtained through the factor analysis and the value of Cronbach's α are shown in Table 2.

Items that failed to get loaded and got deleted from the questionnaire:

Adequate facilities and equipment, office management, knowledge of official procedures, consensus / cohesion in management affairs, continuous personal growth, recognition of work carried out, politeness and courtesy, orderly environment conducive to teaching, clearly specified values and aims, security of job.

Second Questionnaire: Faculty

Similarly, 27 items were identified from the literature review. These were tested for validity which identified 19

Table 2: Variables, Items and Cronbach's α for First Questionnaire:

Administrative / Support staff

S.No.	Variable	No. of items	Items	α
1	Tangibles	3	Proper Physical facilities / Infrastructure, Salary, allowances and benefits	.7151
2	Attitude	5	Effective problem solving / complaint handling, Information sharing and exchange, cordial interpersonal relations, supportive superiors, proper monitoring systems and evaluation procedures	.7850
3	Delivery	3	Autonomy of work / freedom, in-service training and development, individualised/ Personalised attention.	.5637
4	Reliability	3	Consistency of practice, Clearly specified policies/ guidelines, fairly and firmly enforced rules and regulations	.8344

Table 3: Variables, Items and Cronbach's α for Second Questionnaire:

Faculty

S. No.	Variable	No. of items	Items	α
1	Tangibles	5	Appropriate physical facilities/ Infrastructure, adequate facilities and equipment and benefits, adequate and efficient teaching assistants / project help / secretarial help	.6845
2	Competence	3	Effective classroom management, proper classroom procedures, opportunity, control for curriculum development/preparation	.5893
3	Attitude	3	Effective problem solving/complaint handling, cordial interpersonal relations	.6845
4	Delivery	5	In-service training and development, continuous personal growth, politeness and courtesy, orderly environment conducive to teaching, individualized/personalized attention	.7486
5	Reliability	3	Fairly and firmly enforced rules and regulations, Security of job, recognition for work carried out	.6222

items out of a total of 27 items. These got grouped under five factors / constructs for customer requirements and these factors were termed as tangibles, competence, attitude, delivery and reliability.

1. Tangibles: Appropriate physical facilities / infrastructure, adequate facilities and equipment, salary, allowances and benefits, adequate and efficient teaching assistants / project help / secretarial help.
2. Competence: Effective classroom management, proper classroom procedures, opportunity, control for curriculum development/ preparation.
3. Attitude: Effective problem solving / complaint handling, cordial interpersonal relations, proper monitoring systems and evaluation procedures.
4. Delivery: In-service training and development, continuous personal growth, politeness and courtesy, orderly environment conducive to teaching, individualised / personalised attention.
5. Reliability: Fairly and firmly enforced rules and regulations, security of job, recognition for work carried out.

The Cronbach's α values for the different factors of customer requirements ranged from .5893 to .7486 indicating that the scale was internally consistent and reliable (Cronbach, 1951b; Nunnally, 1978b).The variables, with their respective items obtained through the factor analysis and the value of Cronbach's α are shown in Table 3.

Items that failed to get loaded and got deleted from the questionnaire:

Information sharing and exchange, Supportive superiors, Rapport with students, Consensus / cohesion in management affairs, Autonomy of work / freedom, Clearly specified values and aims, Consistency of practice, Clearly specified policies / guidelines.

Third Questionnaire: Students

The questionnaire comprised 38 items as identified from the literature review (See Table 1). Tests for validity through Rotated Component Matrix identified 26 items out of a total of 38 items. These were grouped under five factors/constructs for customer requirements and these factors were termed as competence, attitude, content, delivery and reliability.

1. Competence: Appropriate physical facilities / infrastructure, faculty's expertise, faculty's teaching ability and skills, sufficient faculty / support staff.
2. Attitude: Effective problem solving, orientation towards achievement, healthy competitive environment, willingness to help, politeness and courtesy, cooperative environment.
3. Content: Learn to apply, clarity of course objectives, relevance of curriculum to future needs, flexibility of knowledge being cross-disciplinary.
4. Delivery: Ease of contact / access to teachers and administrative staff, effective classroom management, adequate and appropriate classroom procedures, responsiveness, reward structure / recognition for work done, record keeping on performance, orderly environment.
5. Reliability: Clearly specified values and aims, consistency of practice, clearly specified policies/ guidelines, fairly and firmly enforced rules and regulations, adherence to course objectives.

The Cronbach's α values for the different factors of customer requirements ranged from .6749 to .8017 in-

Table 4: Variables, Items and Cronbach's α for Third Questionnaire:

Students

S.No.	Variable	No. of items	Items	α
1	Competence	4	Appropriate physical facilities/ infrastructure, faculty's expertise, faculty's teaching ability and skills, sufficient faculty / support staff	.6749
2	Attitude	6	Effective problem solving, orientation towards achievement, healthy competitive environment, willingness to help, politeness and courtesy	.7718
3	Content	4	Learn to apply, clarity of course objectives, Relevance of curriculum to future needs, flexibility of knowledge being cross disciplinary	.6928
4	Delivery	7	Ease of contact / access to teachers and administrative staff, effective classroom management, adequate and appropriate classroom procedures, responsiveness reward structure / recognition for work done, record keeping on performance, orderly environment	.8017
5	Reliability	5	Clearly specified values and aims, consistency of practice, clearly specified policies / guidelines, fairly and firmly enforced rules and regulations, adherence to course objectives	.7163

Table 5: Variables, Items and Cronbach's α for Fourth Questionnaire:

Industry

Customer Requirements

S. No.	Variable	No. of items	Items	α
1	Tangibles	3	Appropriate infrastructure for conducting placements, visually appealing environment, sufficient staff / support staff	.5620
2	Competence	6	Teaching expertise, core / basic knowledge, specialised / advanced knowledge, decision-making ability, communication skills, interpersonal skills	.5567
3	Delivery	3	Flexibility of knowledge being cross-disciplinary, courtesy, ease of access to the institution	.6285
4	Attitude	3	Risk-taking ability, desire to continue learning, ethics and morality	.7521

dicating that the scale was internally consistent and reliable (Cronbach,1951; Nunnally, 1978) (See Table 4).

Items that failed to get loaded and got deleted from the questionnaire:

Adequate facilities and equipment, visually appealing environment, instructional / educational leadership, opportunities for campus training and placement, information sharing and exchange, interpersonal relations, appropriate classroom hours, maximum learning time, individualised / personalised attention, proper monitoring systems and evaluation procedures, timely feedback on performance, dependability.

Fourth Questionnaire: Industry

For this category of respondents, the items as identified from the literature review identified 26 items (See Table 1). The test for validity identified 15 items out of a total of 26 items. These got grouped under four factors / constructs for customer requirements and these factors were termed as tangibles, competence, delivery and attitude.

1. Tangibles: Appropriate infrastructure for conducting placements, visually appealing environment, sufficient staff / support staff
2. Competence: Teaching expertise, core / basic knowledge, specialized / advanced knowledge, decision-making ability, communication skills, interpersonal skills.
3. Delivery: In-service training and development, continuous personal growth, politeness and courtesy, orderly environment conducive to teaching, individualised / personalised attention
4. Attitude: Risk-taking ability, desire to continue learning, ethics and morality

The Cronbach's α values for the different factors of customer requirements ranged from .5567 to .7521 indicating that the scale was internally consistent and reliable (Cronbach,1951; Nunnally, 1978).The variables,

with their respective items obtained through the factor analysis and the value of Cronbach's α are shown in Table 5.

Items that failed to get loaded and got deleted from the questionnaire:

Adequate facilities and equipment, willingness to help, relevance of curriculum to future needs, responsiveness, individualised / personalised attention, trustworthiness and credibility, consistency in terms of similarly qualified people.

Requirements from students-Analytical ability of students, computer data acquisition/analysis/programming, ability to learn and apply knowledge, teamwork.

Implications of the Study

Educational institutions have begun to realise the significance of customer-centred philosophies and are turning to TQM as a way of managing their affairs. The influence of quality on customer perceptions and thereby consumption behaviour has led some analysts to call quality the single most important factor for long-term competitive success. A widely accepted view on quality in higher education is the degree to which stakeholders' needs and expectations are consistently satisfied. This study is an attempt to identify such requirements so as to be able to design a system that can help fulfil the varied requirements.

Conclusion

The study was conducted with the objective of identifying the various requirements of the administrative/support staff and the faculty as the internal customers of the educational system and the students and the industry as external customers of the educational system. The literature review helped identify certain items/requirements of these categories of customers. These items were tested for reliability and validity, so as to arrive at statistically proven items that could be identified as customer requirements for the various categories of respondents. Certain items got deleted as they failed the test of either validity or reliability.

The items also got grouped under factors, which were identified as constructs. An attempt was made to conceptualise and operationalise the quality construct from research works on service quality (Zeithaml et al., 1985; Cronin and Taylor, 1992, 1994; Teas, 1993, 1994; Parasuraman et al., 1994; Owlia and Aspinwall, 1998). The customer requirements were thus grouped and categorized under six constructs - tangibles, content, attitude, competence, delivery and reliability.

Not oblivious to the need for adaptation to serve the interests of its stakeholders, in terms of greater responsiveness, responsibility, accountability and increased expectations, the educational system has been pressurised to shift its focus from one on quantitative expansion, to one on emphasis on quality. Changes in the socio-cultural, technical and economic fabric all over the world have encouraged a continuous stream of improvements and reforms aimed at restructuring educational institutions. Educational institutions have begun to realise the significance of Total Quality Management. 'Delighting the customer', the core principle of TQM is the rule for survival in the long run. There have been a variety of perspectives about what constitutes a quality higher education and what should be the effective criteria for measuring the quality. Higher education stakeholders – administrators, faculty, students, employers, governments and the society at large have legitimate interests in the outcome of higher education and all have perspectives on what constitutes a quality outcome. A widely accepted view on quality in higher education is the degree to which stakeholders' needs and expectations are consistently satisfied. It is thus important not only to identify the numerous and varied customers of the educational system, but also to identify their requirements and work towards satisfying them. This paper is the result of an empirical study conducted on select higher educational institutions in India to identify the various customer requirements. On the basis of these findings a quality oriented educational system may be designed that can fulfill the varying expectations from the stakeholders and thereby lead to customer delight and satisfaction.

References

Ashworth, A. and Harvey, R.C. (1994), Assessing Quality in Further and Higher Education, Jessica Kingsley Publishers.

Billing, D. (1996), "Managing Quality Policy and Projects in a University", Total Quality Management, Vol.7, No.2, April, 1996, Carfax Publishing Ltd.

Binney, C. (1992), Making Quality Work: Lessons from Europe's Leading Companies (London, The Economist Intelligence Unit), Quoted in Boaden, R.J. (1997), "What is Total Quality Management and Does it Matter?" Total Quality Management, Vol.8, No. 4, August, 1997, Carfax Publishing Ltd.

Boaden, R.J. (1997), "What is Total Quality ManagementAnd does it Matter?" Total Quality Management, Vol.8, No. 4, August, 1997, Carfax Publishing Ltd.

Bollington, R., Hopkins, D. and West, M. (1990), An Introduction to Teacher Appraisal, Cassell Educational Ltd.

Brower, M. (1991), "The Paradigm Shifts Required to Apply TQM and Teams in Higher Education. Quoted in Pitman, G., Motwani, J., Kumar, A. and Cheng, C.H. (1995), 'QFD Application in an Educational Setting: A Pilot Field Study", International

Journal of Quality and Reliability Management, Vol.12, No.6, MCB University Press.

Cronbach, L.J. (1951), "Coefficient Alpha and the Internal Structure of Test", Psychometrica, Vol.16, pp 297-300.

Cronin, J.J. and Taylor, S.A. (1992), "Measuring Service Quality: A Re-Examination and Extension", Journal of Marketing, 56, pp 55-68.

Cronin, J.J. and Taylor, S.A. (1994), "SERVPERF Versus SERVQUAL: Reconciling Performance-Based and Perceptions-Minus-Expectations Measurement of Service Quality", Journal of Marketing, 58, January, pp 125-31.

Downey, C.J., Frase, L.E. and Peters, J.J. (1994), "The Quality Education Challenge", Corwin Press Inc., A Sage Publication, Thousand Oaks, CA.

Edmonds, R.R. (1979), "Effective Schools for the Urban Poor", Educational Leadership, 37 (15-18), pp 20-24. Quoted in Reid, K., Hopkin, D. and Holly, P. (1987), Towards an Effective School -The Problems and Some Solutions, Basil Blackwell Ltd.

Ewell, P. (1993), "Total Quality and Academic Practice", Change, May-June, 1993, pp 58-64.

Frazier, A. (1997), A Roadmap for Quality Transformation in Education, St.Lucie Press.

Gurnani, H. (1999), "Pitfalls in TQM Implementation: The Case of a Hong Kong Company", Total Quality Management, Vol.10, No.2, 1999, pp 209-228.

Harris, J.W., (1992), "Key Concepts for Quality Improvement for Higher Education." In Harris J.W. and Baggett, M. (Ed.) (1994), Quality Quest in the Academic Process (Birmingham, Samford University).

Harvey, L., Burrows, A. and Green, D. (1992), Criteria of Quality, QHE, Birmingham.

Harvey, L., Burrows, A. and Green, D. (1993), Quoted in Harvey, L. and Knight, P.T. (1996), Transforming Higher Education, SRHE and Open University Press, Buckingham.

Harvey, L. and Green, D. (1994), Quoted in Harvey, L. and Knight, P.T. (1996), Transforming Higher Education, SRHE and Open University Press, Buckingham.

Harvey, L. and Knight, P.T. (1996), Transforming Higher Education, SRHE and Open University Press, Buckingham.

Hau, I. (1991), "Teaching Quality Improvement by Quality Improvement in Teaching", Report No.59, Centre for Quality and Productivity Improvement, University of Winconsin Madison, 1991.

Hitmann, J.A. (1993), "TQM and CQI in Post-Secondary Education', Quality Progress", 26, pp 77-80.

Horne, H. and Pierce, A. (1996), "A Practical Guide to Staff Development and Appraisal in Schools", Kogan Page.

Kanji, G.K. and Tambi, A.M.A. (1999), "TQM in UK Higher Education Institutions", Total Quality Management, Vol.10, No.1, 1999, pp 129-153, Carfax Publishing Ltd.

Kanji, G.K., Tambi, A.M.A. and Wallace, W. (1999), "A Comparative Study of Quality Practice in Higher Education Institutions in the US and Malaysia", Total Quality Management, Vol.10, No. 3, pp 357-371, Carfax Publishing Ltd.

Kearney, M. (1998), "Higher Education and Graduate Employment: Responding to the Challenges of a Changing World", New Frontiers in Education, Vol.28, No.2, Apr-June, 1998.

Krajewski, R.J., Martin, J.S. and Walden, J.C. (1983), The Elementary School Principalship: Leadership for the 1980's, CBS College Pub.

Leblanc, G. and Nguyen, N. (1997), "Searching for Excellence in Business Education: An Exploratory Study of Customer Impressions of Service Quality", International Journal of Educational Management, Vol.11, No.2, 1997, pp-72-79, MCB University Press.

Lembcke, B.A. (1994), "Organizational Performance Measures: The Vital Signs of TQM Investments", New Directions for Higher Education, No.86, Summer, 1994, Jossey-Bass Publishers.

Lewis, R.G. and Smith, D.H. (1994), Total Quality in Higher Education, St. Lucie Press.

Lezotte, L. (1989), "School Improvement Based on the Effective Schools Research", International Journal of Educational Research, Vol.13, No.17, pp 815-825.

Lozier, G.G. and Teeter, D.J. (1996), "Quality Improvement Pursuits in American Higher Education", Total Quality Management, Vol.7, No.2, April, 1996, Carfax Publishing Ltd.

Madu, C.N., Kuei C. H. and Winokur, D. (1994), "TQM in The University: A Quality Code of Honor", Total Quality Management, Vol.5 and 6,1994, pp 375-390, Carfax Publishing Ltd.

Marchese, T. (1991), "TQM Reaches the Academy", American Association For Higher Education Bulletin, November, 1991, pp 433-446. Quoted in Pitman, G, Motwani, J., Kumar, A. and Cheng, C.H. (1995), "QFD Application in an Educational Setting: A Pilot Field Study", International Journal of Quality and Reliability Management, Vol. 12, No.6, MCB University Press.

Marchington, M. (1992), Developing Employee Involvement, Oxford, Blackwell.

Michael, R.K., Sower, V.E. and Motwani, J. (1997), "A Comprehensive Model for Implementing TQM in Higher Education", Benchmarking for Quality Management and Technology, Vol. 4, No.2, MCB University Press.

Mortimore, P., Sammons, P., Ecob, R. and Stoll, L. (1988), School maters - The Junior Years, Salisbury: Open Books. In OECD (Ed.)(1992), The OECD International Education Indicators- A Framework For Analysis, OECD, Paris, 1992.

Nadeau (1993). Quoted in Harvey, L. and Knight P.T. (1996), Transforming Higher Education, SRHE and Open University Press, Buckingham.

Nunnally, J.C. (1978), "Psychometric Theory", Mcgraw Hill, New York.

Owlia, M.S. and Aspinwall, E.M. (1996 a), "Quality in Higher Education - A Survey", Total Quality Management, Vol.7 No.2, April, 1996, Carfax Publishing Ltd.

Owlia, M.S. and Aspinwall, E.M. (1996 b), "A Framework for the Dimensions of Quality in Higher Education", Quality Assurance in Education, Vol.4, No.2, 1996, pp 12-20, MCB University Press.

Owlia, M.S. and Aspinwall, E.M. (1998), "A Framework for Measuring Quality in Engineering Education", Total Quality Management, Vol.9, No.6, August, 1998, Carfax Publishing Ltd.

Parasuraman, A., Berry, L.L. and Zeithaml, V.A. (1994), "Reassessment of Expectations as a Comparison Standard in Measuring Service Quality Implications for Future Research", Journal of Marketing, Vol.58, No 1.

Parasuraman, A., Zeithaml, V.A. and Berry, L.L. (1985), "A Conceptual Model of Service Quality and its Implications for Future Research", Journal of Marketing, Vol. 49, No.4, pp 41-50.

Pitman, G., Motwani, J., Kumar, A. and Cheng, C.H. (1995), "QFD Application in an Educational Setting: A Pilot Field Study", International Journal of Quality and Reliability Management, Vol.12, No.6, MCB University Press.

Parasuraman, A., Zeithaml, V.A. and Berry, L.L. (1994), "Alternative Scales for Measuring Service Quality: A Comparative Assessment Based on Psychometric and Diagnostic Criteria", Journal of Retailing, Vol. 70, No.3, pp 201-230. Quoted in Kuei, C. and Lu, M.H. (1997), 'An Integrated Approach to Service Quality Improvement', International Journal of Quality Science, Vol.2, No.1, 1997, pp 24-36, MCB University Press.

Raisbeck, I. (1994), Royal Mail: Developing a Total Quality Organization. In Green, D. (Ed.) (1994), What is Quality in Higher Education? SRHE and Open University Press, Buckingham.

Redfern, G.B. (1980), Evaluating Teachers and Administrators: A Performance Objectives Approach, Westview Press Inc.

Rhodes, L.A. (1992), "On the Road to Quality", Educational Leadership, Vol.50, March, 1992, pp 76-80.

Rutter, M., Maugham, B., Mortimore, P. and Oustan, J. (1979), Fifteen Thousand Hours: Secondary Schools and their Effects on Childeren, Wells, Open Books.

Sahney, S., Karunes, S. and Banwet, D.K. (2001), "Total Quality Management in Higher Education The What and the Why?" Journal of Educational Planning and Administration, Vol.XV, No.1, January, 2001, pp 97-104.

Sahney, S., Banwet, D.K. and Karunes, S. (2004), "Conceptualizing Total Quality Management in Higher Education", The TQM Magazine, Emerald, Vol.16, No.2, pp145-159.

Sahney, S., Banwet, D.K. and Karunes, S. (2004), "Customer Requirement Constructs: the Premise for TQM in Education: A Comparative Study of Select Engineering and Management Institutions in the Indian context", International Journal of Productivity and Performance Management, Emerald, Vol. 53 No. 6, 2004, pp. 499-520.

Sallis, E. (1993), "TQM in Education", London, Kogan Page.

Scheerens, J. (1989), Wat Maakt Scholen Effectif? Samenvalting En Analyse Van Onderzoeksresultaten, Den Haag: Stitching Voor Onderzoekvan Het Ondervijs. Quoted in the OECD (Ed.) (1992), International Education Indicators - A Framework for Analysis, OECD, Paris.

Scheerens, J. (1992), Process Indicators for School Functioning. In the OECD (Ed.) (1992), International Education Indicators - A Framework for Analysis, OECD, Paris.

Scheerens, J. and Bosker, R.J. (1997), The Foundation of Educational Effectiveness, Elsevier Science Ltd., Pergamon.

Sirvanci, M. (1996), "Are Students the True Customers of Higher Education" Quality Progress, 1996, pp 99-102.

Spanbauer, S.J. (1995), "Reactivating Higher Education with Total Quality Management: Using Quality and Productivity Concepts, Techniques and Tools to Improve Higher Education", Total Quality Management, Vol. 6, No.5 and 6, 1995.

Suganthi, L., Samuel, A.A. and Jagadeesan, T.R. (1998), "Failure Mode and Effect Analysis as a Preventive Tool for Quality Improvement in Education", The Indian Journal of Technical Education, Vol.21, No. 3, July-Sept, 1998.

Tang, K.H. and Zairi, M. (1998), "Benchmarking Quality Implementation in a Service Context: A Comparative Analysis of Financial Services and Institutions of Higher Education-Part III", Total Quality Management, Vol.9, No.8, 1998, pp 666-679, Carfax Publishing Ltd..

Teas, R.K. (1993), "Expectations, Performance Evaluation and Consumer's Perception of Quality", Journal of Marketing, Vol.57, No.10, pp18-34.

Teas, R.K. (1994), "Expectations as a Comparison Standard in Measurement of Service Quality: An Assessment of a Reassessment", Journal of Marketing, Vol. 58, January.

The Conference Board, (1993), Does Quality Work? A Review of Relevant Studies (New York, The Conference Board). Quoted in Boaden, R.J. (1997), "What is Total Quality Management-And Does it Matter?" Total Quality Management, Vol. 8, No. 4, August, 1997, Carfax Publishing Ltd.

Tomlinson, (1980). Quoted in Reid, K., Hopkins, D. and Holly P., (1987), Towards an Effective School -The Problems and Some Solutions, Basil Blackwell Ltd.

Trethowan, D. (1987), Appraisal and Target Setting - A Handbook for Teacher Development, Harper And Row Publishers.

Tuttle, T.C. (1994), "Is Total Quality Worth The Effort' How do we Know" New Directions for Higher Education, No.86, Summer, 1994, Jossey Bass Publishers.

West-Burnham, J. (1992), "Managing Quality in Schools-A TQM Approach", Longman Group UK Ltd.

Winch C. (1996), "Quality and Education", Blackwell Publishers.

Zeithaml, V.A., Parasuraman, A. and Berry, L.L. (1985), "Problems and Strategies in Services Marketing", Journal of Marketing, Vol.49, Spring, pp33-46. □

Assumptions allow the best in life to pass you by.

– John Sales

Feature

Resources Utilisation: A Study of Public Sector Enterprises in India

P.K. Jain & Surendra S. Yadav

The efficiency with which resources are used by a business enterprise has a marked bearing on its profitability. To measure the efficiency, the ratios such as total assets turnover ratio, fixed assets turnover ratio, capacity utilization ratio and current assets turnover ratio have been calculated and analysed. For the study, secondary data has been used, pertaining to 137 PSEs for a period of 13 years, from 1991 to 2003, taken from Prowess Database of the CMIE.

P.K. Jain and Surendra S. Yadav are Professors of Finance at the Department of Management Studies, IIT, Delhi.

The objective of this paper is to assess the financial performance of central public sector enterprises (PSEs) primarily in terms of efficiency with which they use their resources.

The profit test is one of the important tests of economic efficiency, that is, whether the resources are gainfully employed or not and whether the business enterprise is operating competitively or not. It has a direct bearing on the PSE's ability to function as a successful business firm. Besides, it is consistent with the present Government's philosophy that public sector enterprises should not only be financially self-sufficient but should also generate commercial surpluses with which further economic development can be financed. Further, their ability to tap capital market by issuing equity shares and bonds/debentures would depend on their financial viability. Above all, the PSEs can discharge their social responsibilities only when they are profitable.

The efficiency with which resources are used by a business enterprise has a marked bearing on the profitability of a business firm/PSE. Therefore, the major efficiency ratios showing use of current assets, fixed assets and total assets have been analysed in this paper.

Scope and Methodology

The scope of this study is limited to non-financial central PSEs engaged in manufacturing and service rendering businesses. The sample consists of 137 such enterprises (out of total 230 operating central PSEs as on 31st March, 2002). The sample is representative in nature as it adequately represents all industry groups (as per the classification of the Public Enterprises Survey) as shown in Table 1. The sample covers more than six-tenths of the total non-financial operating PSEs from a statistical point of view. It is reasonable to assume that the sample is a true representative of the universe of PSEs.

Table 1: Industry-wise classification of central public sector enterprises covered by the study

S. No	Industry	Total no of PSEs	PSEs covered in sample	Percentage (%)
I	Manufacturing			
1	Steel	7	5	71.43
2	Minerals & Metals	11*	8	72.73
3	Coal & Lignite	9	5	55.56
4	Power	4	3	75
5	Petroleum	14	13	92.86
6	Fertilizers	8	6	75
7	Chemicals & Pharmaceuticals	21	8	38.1
8	Heavy Engineering	15	8	53.33
9	Medium & Light Equipment	23	16	69.57
10	Transportation Equipment	12	9	75
11	Consumer Goods	18**	8	44.44
12	Textiles	14	12	85.71
	Total no. of companies	156	101	64.74
II	Services			
1	Trading & Marketing	18	11	61.11
2	Transportation Services	9	8	88.89
3	Contracts & Construction	10	6	60
4	Industrial Dev. & Technical Consultancy	13	6	46.15
5	Tourist Services	9	3	33.33
6	Telecommunication Services	2	2	100
	Total no. of companies	61	36	59.02
III	Total	217[$]	137	63.13

* Bharat Aluminium Co. Ltd.

** Modern Food Industries (India) Ltd. These companies are excluded due to privatization.

@ Excludes 4 PSEs from agro-based industries and 9 PSEs registered under Section 25 of Companies Act (as they are non-commercial in nature). After excluding these 13 enterprises the universe consists of 217 PSEs.

The relevant data (secondary) on the first aspect were collected from the Centre for Monitoring Indian Economy, CMIE's Prowess Database for 13 years (1990-91 to 2002-3). While the data for 1991-2002 relate to 137 PSEs, data in respect of the lower number of enterprises was available for year 2003. Further, the sample size varies on a year-to-year basis on account of year of incorporation of the sample PSE and availability of data.

The 13-year period of the study is divided into two sub-parts. For the purpose of the study/analysis, the first six years (1991-96) phase is referred to as the first/initial phase of economic reforms/liberalization and the latter sub-period (1997-2003) as the second phase of economic liberalization. The 'first' phase and the 'second' phase are considered as two independent samples. We have used 't' test and 'analysis of variance' to ascertain whether there exists a significant difference in the performance of the sample PSEs during these two phases.

To study the trend and its implications, the descriptive statistical values/positional values, i.e., mean, median and quartiles, have been computed for each year. To do away with the influence of extreme values, they have been excluded from computing average values. However, where their inclusion has been considered important, say, for preparation of frequency distribution, the extreme values are also considered.

The analysis of data has been made separately of the sample PSEs engaged in manufacturing activities and those rendering services (hereafter referred to as manufacturing PSEs and service PSEs), as there is a significant difference in their nature of business. Their combined analysis would have given distorted results. The entire set of data has been analysed using the software, Statistical Package for Social Sciences (SPSS).

Efficiency Ratios

Efficiency ratios are concerned with measuring the efficiency with which assets are used in a business enterprise by its management. For this reason, they are aptly referred to as *assets utilization ratios*. Obviously, such ratios will have a marked bearing on profitability of PSEs. Other things being equal, the more efficient is the utilization of assets, the higher/better the profitability of PSEs.

Turnover is the primary mode for measuring the extent of efficient employment of assets by relating them to sales (more appropriately with cost of sales/ cost of production) as denominator is also at cost price. The greater the rate of turnover or conversion, the more efficient the utilization of assets.

In contrast, low turnover ratios are indicative of

under-utilisation of available resources and presence of idle capacity. The objective of this paper is to describe the major efficiency ratios, namely, total assets turnover ratio, fixed assets turnover ratio, and capacity utilisation ratio and current assets turnover ratio of the public sector enterprises. In computing the first two ratios, the total assets are net of depreciation and are exclusive of fictitious assets like debit balance of profit and loss account, deferred expenditures and so on.

Total Assets Turnover Ratio (TATR)

TATR measures the relationship between the cost of sales and average total assets of a PSE. Relevant data pertaining to TATR indicate that the PSEs, *prima-facie,* do not seem to have satisfactory TATR. For instance, in the case of manufacturing PSEs (Table 2), the highest TATR was 1.16 in 2003; it was less than 1 in 12 years (1991-2002), the range being 0.71 (1994) and 0.90 (2001). As a result, for the period as whole, the mean value was at an unsatisfactory figure of 0.83. The median at 0.64 manifests a more dismal situation. Quartile values indicate that 50 per cent of the sample PSEs have TATR in size range of 0.36-1.05.

Table 2: Mean, median and quartile values related to total assets turnover ratio of sample manufacturing PSEs, 1991-2003

(Figures are in percentages)

Year	Number	Mean	Median	Quartile 1	Quartile 3
1991	97	0.78	0.58	0.32	0.89
1992	98	0.78	0.57	0.36	1.00
1993	98	0.74	0.57	0.35	0.91
1994	98	0.71	0.61	0.27	0.98
1995	99	0.77	0.58	0.31	0.98
1996	99	0.84	0.67	0.34	1.09
1997	98	0.87	0.66	0.38	1.11
1998	97	0.84	0.65	0.37	1.05
1999	90	0.89	0.67	0.41	1.08
2000	96	0.87	0.74	0.41	1.06
2001	101	0.90	0.71	0.41	1.09
2002	80	0.86	0.65	0.34	1.08
2003	32	1.16	0.87	0.54	1.79
1991-96	97-99	0.77	0.59	0.34	0.99
1997-03	32-101	0.88	0.68	0.38	1.10
1991-03	32-101	0.83	0.64	0.36	1.05

Note: The extreme values of TATR of 10 or more are excluded.

Paired samples test

	Paired differences							
Difference Significant	Mean	Std. Dev.	Std. Mean Error	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
(1991-96 and 1997-2003)	-0.11	0.42	0.04	-0.20	-0.03	-2.59	98	0.01

Likewise, the TATR related to service PSEs *albeit* higher than manufacturing enterprises are also low. The respective mean and median values are 1.11 and 0.63 for the entire period of the study (Table 3).

Table 3: Mean, median and quartile values related to total assets turnover ratio of sample service PSEs, 1991-2003

(Figures are in percentages)

Year	Number	Mean	Median	Quartile 1	Quartile 3
1991	31	1.02	0.47	0.21	1.37
1992	30	0.94	0.47	0.24	1.25
1993	32	1.06	0.56	0.28	1.23
1994	32	1.02	0.62	0.32	1.24
1995	31	1.06	0.49	0.32	1.02
1996	33	1.18	0.64	0.41	1.22
1997	33	1.15	0.71	0.39	1.30
1998	33	1.09	0.57	0.29	1.07
1999	28	1.05	0.73	0.35	1.22
2000	32	1.14	0.82	0.39	1.48
2001	35	1.21	0.82	0.41	1.44
2002	24	1.26	0.72	0.32	1.52
2003	8	1.49	0.57	0.32	2.98
1991-1996	30-33	1.05	0.53	0.27	1.16
1997-2003	8-35	1.16	0.73	0.36	1.32
1991-2003	8-35	1.11	0.63	0.32	1.20

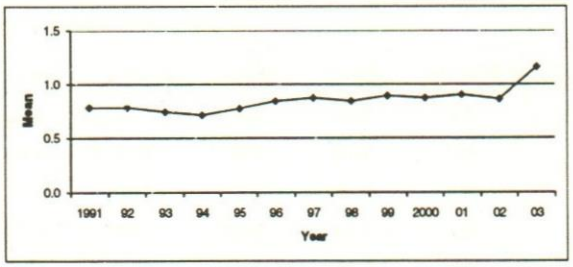
Note: The extreme values of TATR of 10 ore more are excluded.

Paired samples test

	Paired differences							
Difference Significant	Mean	Std. Dev.	Std. Mean Error	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
(1991-96 and 1997-2003)	-0.158	0.348	0.0601	-0.282	-0.035	-2.61	32	0.014

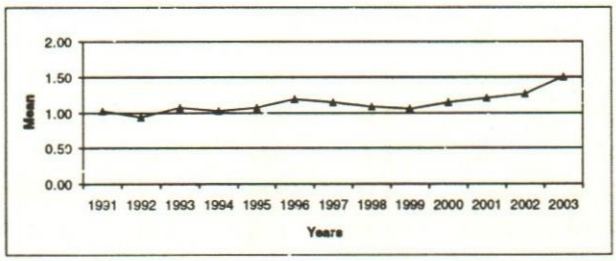
Similar conclusions follow on the basis of frequency distribution tables (Tables 4 and 5). During the entire period of the study, the modal class group of TATR is either 0-0.5 or 0.5-1.0 in respect to both types of PSEs.

However, it is a matter of some satisfaction that there has been an increase in a TATR of both types of PSEs (observed to be statistically significant as per paired samples 't' test) in post-liberalisation phase two *vis-à-vis* phase one. Figures 1 (manufacturing) and 2 (service) portray the rising trend of TATR over the years of the study.



(Figures are in percentages)

Fig. 1. Mean values of cost of sales to average total assets of manufacturing PSEs, 1991-2003



(Figures are in percentages)

Fig. 2. Mean values of cost of sales to average total assets of services PSEs, 1991-2003

In sum, it is reasonable to conclude that the TATR of the sample PSEs seem to be far from satisfactory, notwithstanding the increase in phase two. In operational terms, the data eloquently testify that the PSEs, in general, are carrying higher level of assets than warranted by their level of operations (measured in terms of cost of sales). Further, no significant difference is observed in respect of TATR when it is computed with reference to sales (refer to Appendix Tables A.1 and A.2).

Fixed Assets (net) Turnover Ratio (FATR)

In contrast, FATR (measured on the basis of the relationship between cost of production and average net fixed assets presents a better picture of utilization of fixed assets by the PSEs. For instance, the mean FATR of manufacturing enterprises has been either 3 or more than 3 in 12 out of 13 years covered by the study, the mean figure being 3.24 (Table 6). The upper quartile value of 5.03 signifies that one-fourth of manufacturing PSEs had FATR of more than 5; only one-fourth of such enterprises had FATR of less than 1.12. Similar conclusions follow on the basis of frequency distribution table (Table 7). The modal class group of FATR is 5-10 during 1996-2003; in earlier years (1991-95), it is either 3-5 or 1.5-3.

Table 4: Frequency distribution related to TATR of sample manufacturing PSEs, 1991-2003

(Figures are in percentages)

TATR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0-.5	40.2	38.8	38.8	42.9	41.4	32.3	35.7	39.2	33.3	33.3	34.7	37.5	25.0
.5-1	37.1	35.7	39.8	32.7	34.3	40.4	33.7	33.0	38.9	37.5	38.6	35.0	31.3
1-1.5	11.3	14.3	12.2	15.3	13.1	12.1	12.2	13.4	12.2	18.8	13.9	11.3	15.6
1.5-2	4.1	5.1	5.1	6.1	4.0	6.1	11.2	8.2	5.6	0.0	5.0	8.8	15.6
2-10	7.2	6.1	4.1	3.1	7.1	9.1	7.1	6.2	10.0	10.4	7.9	7.5	12.5
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 5: Frequency distribution related to TATR of sample service PSEs, 1991-2003

(Figures are in percentages)

TATR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0-.5	51.6	58.1	45.5	42.4	53.1	38.2	35.3	44.1	34.5	27.3	30.6	37.5	50.0
.5-1	16.1	16.1	21.2	30.3	21.9	35.3	32.4	29.4	37.9	39.4	27.8	25.0	25.0
1-1.5	9.7	12.9	15.2	6.1	9.4	8.8	11.8	5.9	6.9	12.1	22.2	12.5	0.0
1.5-2	9.7	3.2	3.0	6.1	0.0	0.0	2.9	2.9	6.9	6.1	2.8	4.2	0.0
2-10	12.9	9.7	15.2	15.2	15.6	17.6	17.6	14.7	10.3	12.1	13.9	20.8	25.0
10 and above	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	3.4	3.0	2.8	0.0	0.0
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total No.	31	31	32	32	31	33	33	34	28	33	36	24	8

Likewise, the mean FATR of 2.81 (for 1991-2003) in respect of service PSEs seems to be indicative of satisfactory utilisation of capacity available with them (Table 8). However, *inter-se,* this performance is not evenly distributed. For instance, one-fourth of the service enterprises have very low FATR of 0.66 or less (as per quartile 1); the next one fourth of service PSEs have FATR in the range of 0.66-1.42 (as per median).

In brief, it is apparent while a vast majority of manufacturing enterprises have satisfactory utilisation of fixed assets, the same is not true for sizeable number of service PSEs.

Capacity Utilisation Ratio

To have a more candid picture on the utilisation of fixed assets, we have attempted to determine capacity utilisation ratio (CUR) of manufacturing PSEs from data available in the Public Enterprises Survey. The ratio was determined on the basis of data contained in various issues of Public Enterprises Survey. Therefore, the sample size relating to CUR of the section is more comprehensive than the sample size of the study. This point should be borne in mind while interpreting the results.

It is apparent from the data in Table 9 that there is an under utilisation of capacity in a large number of manufacturing PSEs. It is manifested in the fact that the CUR in size ranges of: (i) 75-100 per cent and (ii) above 100 per cent of installed/rated capacity was only for more than half (maximum 59.3 per cent in 2001) of the manufacturing enterprises and that too only in 4 out of 11 years (1991-2001). In other words, it implies that less than half (nearly 40 per cent) of these PSEs operated much below their capacity in 7 out of 11 years covered in analysis. Further, about one-sixth to one-fifth of enterprises operated at only one-fourth of their capacity.

Table 6: Mean, median and quartile values of FATR pertaining to sample manufacturing PSEs, 1991-2003

(Figures are in percentages)

Year	Number	Mean	Median	Quartile 1	Quartile 3
1991	86	3.00	2.44	1.10	4.32
1992	88	3.18	2.66	1.15	4.62
1993	93	3.25	2.51	1.32	5.20
1994	95	3.13	2.62	1.10	4.71
1995	91	2.89	2.50	1.01	4.40
1996	92	3.26	2.71	1.16	5.00
1997	90	3.48	2.68	1.15	5.67
1998	86	3.14	2.20	1.00	5.34
1999	82	3.23	2.78	1.02	5.18
2000	83	3.33	2.81	1.09	5.26
2001	91	3.56	3.45	1.39	5.27
2002	73	3.36	2.64	1.27	5.03
2003	28	3.40	2.42	0.97	5.31
1991-96	88-95	3.12	2.54	1.11	4.70
1997-03	28-91	3.36	2.74	1.13	5.32
1991-03	28-95	3.24	2.59	1.12	5.03

Note: The extreme values of FATR of 10 or more are excluded.

Paired samples test

Paired differences								
Difference Significant	Mean	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
(1991-96 and 1997-2003)	-0.33	1.47	0.15	-0.63	-0.03	-2.19	93	0.03

As per trend, it is pertinent to note that in years 2001 and 2002 there was a larger number of PSEs in the range of 75-100 per cent and above 100 per cent,

Table 7: Frequency distribution of FATR related to sample manufacturing PSEs, 1991-2003

(Figures are in percentages)

FATR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0-.5	10.3	6.2	9.2	10.2	10.1	10.1	9.2	11.3	7.8	5.2	4.0	6.3	3.1
.5-1	10.3	13.4	9.2	13.3	12.1	9.1	7.1	11.3	15.6	15.6	11.9	15.0	21.9
1-1.5	13.4	8.2	8.2	5.1	11.1	14.1	13.3	8.2	8.9	8.3	7.9	6.3	6.3
1.5-3	18.6	22.7	27.6	25.5	18.2	16.2	18.4	23.7	15.6	15.6	18.8	20.0	15.6
3-5	18.6	22.7	15.3	21.4	22.2	20.2	14.3	8.2	17.8	17.7	21.8	20.0	15.6
5-10	17.5	17.5	25.5	21.4	18.2	23.2	29.6	25.8	25.6	24.0	25.7	23.8	25.0
Above 10	11.3	9.3	5.1	3.1	8.1	7.1	8.2	11.3	8.9	13.5	9.9	8.8	12.5
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 8: Mean, median and quartile values of FATR pertaining to sample service PSEs, 1991-2003

(Figures are in percentages)

Year	Number	Mean	Median	Quartile 1	Quartile 3
1991	20	2.73	1.12	0.54	5.90
1992	16	1.81	0.86	0.60	1.65
1993	19	2.86	1.72	0.64	4.66
1994	19	2.16	1.54	0.63	3.38
1995	21	3.07	1.84	0.65	4.62
1996	21	3.46	2.21	0.67	6.29
1997	21	3.40	2.45	0.72	6.26
1998	23	3.33	2.53	0.68	5.66
1999	19	3.34	2.03	0.77	4.95
2000	18	2.64	1.59	0.78	3.58
2001	18	2.46	1.32	0.71	3.52
2002	12	1.67	1.00	0.47	1.57
2003	5	2.79	1.35	0.76	5.54
1991-1996	16-21	2.72	1.18	0.60	3.87
1997-2003	5-23	2.90	1.57	0.75	3.70
1991-2003	5-23	2.81	1.42	0.66	3.71

Note: The extreme values of FATR of 10 or more are excluded.

Paired samples test

	Paired differences					t	df	Sig. (2-tailed)
	Mean	Std. Dev.	Std. Mean Error	95% Confidence Interval of the Difference				
				Lower	Upper			
Difference Significant (1991-96 and 1997-2003)	-0.33	1.47	0.15	-0.63	-0.03	-2.19	93	0.03

signifying better capacity utilisation trend. This may be attributed to various steps taken by the Government to improve their performance. The important measures, *inter-alia,* include: (i) signing of Memorandum of Understanding (MOU) with PSEs, (ii) delegation of enhanced powers to board of directors particularly of Navratna and Miniratna PSEs, (iii) professionalisation of board of directors, (iv) training and human resources development, (v) technology upgradation, research and development and (vi) improved maintenance (Public Enterprises Survey, 2002).

In operational terms, it implies that the sizeable number of manufacturing PSEs can expand their activity level (in terms of production and sales) without requiring additional capital investments. However, it would be feasible only when plant and machinery of these PSEs is not obsolete (technologically).

Current Assets Turnover Ratio (CATR)

A *priori*, it is hypothesized that the CATR of the sample PSEs is likely to be low. There are two reasons for this: (i) the sample PSEs were observed to have a long span of gross working capital cycle (Tables A.3 and A.4) and (ii) the sample PSEs have low TATR. The relevant data contained in Tables 10 and 11 provide empirical evidence for the same.

One-fourth of the manufacturing enterprises had CATR of 0.65 or less; the next one-fourth had this range from 0.65-1.03 (Table 10). Only in the case of another 25 per cent such PSEs, the CATR was 1.69 or more.

As per trend also, there is no significant difference in mean values of two sub-phases of the study. Frequency distribution data (Table 12) further testify it in that the modal class group of CATR is 0.5-1.0 for 12 years (1991-2002) of the study. Only in respect of nearly one-sixth manufacturing PSEs, the CATR exceeded two in most of the years covered by the study.

Table 9: Capacity utilised (%) by public sector manufacturing enterprises, 1991- 2001

Capacity utilised	1991		1992		1993		1994		1995		1996		1997		1998		1999		2000		2001	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Below 10	5	3.9	6	4.7	5	4.2	9	7.2	9	7.4	10	8.1	11	8.9	14	11.4	16	13.3	9	8.1	10	10.0
10-25	10	7.9	6	4.7	7	5.9	8	6.4	10	8.2	9	7.3	12	9.7	11	9.0	8	6.6	12	10.9	5	5.0
25-50	22	17.4	24	18.8	21	17.7	22	17.7	25	20.6	16	13.0	22	17.8	22	18.0	19	15.8	16	14.5	12	11.8
50-60	13	10.3	10	7.8	9	7.6	13	10.4	6	4.19	13	10.5	7	5.6	2	1.6	6	5	3	2.7	3	2.9
60-75	16	12.6	15	11.8	18	15.2	18	14.5	18	14.8	17	13.8	15	12.1	8	6.5	15	12.5	10	9.0	11	10.8
75-100	35	27.7	39	30.7	29	24.5	30	24.1	28	23.1	31	25.2	34	27.6	36	29.5	29	24.1	32	29.0	32	31.6
Above 100	25	19.8	27	21.2	29	24.5	24	19.3	25	20.6	27	21.9	22	17.8	29	23.7	27	22.5	28	25.4	28	27.7
Total	126		127		118		124		121		123		123		122		120		110		101	

Source: Department of Public Enterprises, Public Enterprises Survey (of various years, N. Delhi)

Table 10: Mean, median and quartile values related to CATR of sample manufacturing PSEs, 1991-2003

(Figures are in percentages)

Year	Number	Mean	Median	Quartile 1	Quartile 3
1991	97	1.29	0.98	0.71	1.64
1992	98	1.33	1.13	0.65	1.68
1993	96	1.19	1.04	0.65	1.43
1994	97	1.16	0.94	0.64	1.52
1995	98	1.27	1.01	0.64	1.69
1996	96	1.33	1.12	0.66	1.85
1997	96	1.29	1.14	0.71	1.78
1998	96	1.30	1.09	0.61	1.71
1999	88	1.40	1.17	0.70	1.62
2000	95	1.30	0.97	0.71	1.64
2001	99	1.28	0.99	0.61	1.76
2002	79	1.38	1.00	0.53	1.97
2003	32	2.04	1.86	0.93	2.74
1991-96	96-98	1.26	1.02	0.65	1.61
1997-03	32-99	1.36	1.05	0.64	1.77
1991-03	32-99	1.31	1.03	0.65	1.69

Note: The extreme values of CATR of 10 or more are excluded.

Paired samples test

Paired differences								
Difference Significant	Mean	Std. Dev.	Std. Mean Error	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
(1991-96 and 1997-2003)	-0.07	0.67	0.07	-0.20	-0.07	-1.02	98	0.31

Table 11: Mean, median and quartile values related to CATR of sample service PSEs, 1991-2003

(Figures are in percentages)

Year	Number	Mean	Median	Quartile 1	Quartile 3
1991	29	1.46	1.17	0.63	2.17
1992	31	1.50	1.18	0.61	1.86
1993	31	1.59	1.34	0.64	2.19
1994	32	1.63	1.23	0.59	2.28
1995	32	1.63	1.09	0.57	2.48
1996	34	1.86	1.03	0.59	2.51
1997	34	1.93	1.43	0.62	2.10
1998	33	1.67	1.22	0.47	1.81
1999	28	1.72	1.39	0.54	2.21
2000	32	1.69	1.28	0.62	2.03
2001	34	1.56	1.39	0.79	2.16
2002	24	2.05	1.51	0.58	2.81
2003	8	2.19	1.19	0.43	3.56
1991-1996	34	1.62	1.11	0.60	2.05
1997-2003	34	1.78	1.30	0.57	1.98
1991-2003	34	1.70	1.19	0.57	2.00

Note: The extreme values of CATR of 10 ore more are excluded.

Paired samples test

Paired differences								
Difference Significant	Mean	Std. Dev.	Std. Mean Error	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
(1991-96 and 1997-2003)	-0.13	0.51	0.09	-0.31	0.05	-1.44	33.0	0.16

Table 12: Frequency distribution related to CATR of sample PSEs (manufacturing), 1991-2003

(Figures are in percentages)

CATR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Less than 0	0.0	0.0	1.0	1.0	0.0	3.0	2.0	0.0	1.1	1.0	2.0	1.3	0.0
0-0.5	17.5	17.3	13.4	20.4	16.2	18.2	17.3	22.9	16.5	21.9	22.8	22.5	6.3
.5-1	34.0	28.6	32.0	32.7	33.3	24.2	25.5	21.9	28.6	30.2	27.7	27.5	28.1
1-1.5	20.6	20.4	33.0	19.4	17.2	20.2	22.4	27.1	20.9	17.7	13.9	16.3	9.4
1.5-2	13.4	17.3	12.4	17.3	17.2	18.2	14.3	12.5	16.5	15.6	15.8	8.8	9.4
2-2.5	10.3	9.2	3.1	5.1	8.1	8.1	8.2	5.2	6.6	4.2	7.9	11.3	9.4
2.5-10	4.1	7.1	5.2	4.1	7.1	8.1	10.2	10.4	7.7	9.4	9.9	12.5	37.5
Above 10	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0

Table 13: Frequency distribution related to CATR of sample PSEs (services), 1991-2003

(Figures are in percentages)

CATR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0-.5	21.9	21.9	21.2	21.2	14.3	14.7	17.6	29.4	20.7	18.2	8.6	12.5	37.5
.5-1	21.9	25.0	12.1	27.3	28.6	32.4	23.5	8.8	17.2	21.2	20.0	25.0	12.5
1-1.5	21.9	18.8	30.3	12.1	14.3	11.8	11.8	23.5	17.2	15.2	22.9	12.5	0.0
1.5-2	0.0	15.6	3.0	12.1	5.7	8.8	20.6	14.7	17.2	15.2	17.1	16.7	12.5
2-5	25.0	15.6	27.3	24.2	31.4	20.6	17.6	14.7	20.7	24.2	25.7	25.0	25.0
Above 5	9.4	3.1	6.1	3.0	5.7	11.8	8.8	8.8	6.9	6.1	5.7	8.3	12.5
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total No.	32	32	33	33	35	34	34	34	29	33	35	24	8

The state of affairs is not significantly different for the service sector PSEs. Though the mean CATR is higher at 1.70 for the entire period of the study (1991-2003), the lower quartile of 0.57 signifies that one-fourth of service enterprises have CATR of 0.57 or less. Based on median value, one-half of the service PSEs have the CATR of 1.19 or less. As per the trend also, there is no significant difference (duly supported by paired samples 't' test) in mean values of two sub-phases of the study (Tables 11). Further, frequency distribution data indicates that nearly one-fourth to one-third of service PSEs only have CATR of 2 or more (Table 13). In brief, the sample PSEs (of both categories) carry excessive working capital.

Concluding Observations

From the above analysis, it is reasonable to conclude that there is an under-utilisation of resources pertaining to fixed assets as well as current assets in respect of a sizeable number of both manufacturing and service PSEs in India. This is likely to cause a dent in profitability of such PSEs. In other words, there is a potential of improving profitability of PSEs by having better utilisation of resources. In view of under-utilised assets available, the PSEs can expand their activity level in terms of production and sales without requiring additional capital investments.

References

Department of Public Enterprises (2002), Public Enterprises Survey, Volume – 1 (New Delhi), page 119.

Table A.1: Mean, median and quartile values of TATR (net sales/average total assets) of sample manufacturing PSEs, 1991-2003

(Figures are in percentages)

Year	Number	Mean	Median	Quartile 1	Quartile 3
1991	92	0.83	0.68	0.38	0.91
1992	97	0.86	0.69	0.37	1.04
1993	98	0.79	0.67	0.33	0.99
1994	97	0.72	0.61	0.26	0.94
1995	98	0.70	0.57	0.32	0.91
1996	98	0.81	0.63	0.33	1.09
1997	96	0.94	0.63	0.32	1.04
1998	96	0.74	0.61	0.27	1.05
1999	87	0.74	0.61	0.31	1.01
2000	89	0.73	0.61	0.36	0.90
2001	95	0.76	0.60	0.29	1.02
2002	80	0.71	0.51	0.25	0.95
2003	31	1.37	0.93	0.61	1.85
1991-96	92-98	0.78	0.64	0.33	1.00
1997-2003	31-96	0.78	0.61	0.30	1.04
1991-2003	31-98	0.78	0.63	0.31	1.01

Note: The extreme values of TATR of 10 or more are excluded.

Paired samples test

	Paired differences							
Difference Significant	Mean	Std. Dev.	Std. Mean Error	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
(1991-96 and 1997-2003)	-0.02	0.41	0.04	-0.11	0.07	-0.42	84	0.67

Table A.2: Mean, median and quartile values of TATR (net sales/average total assets) of sample service PSEs, 1991-2003

(Figures are in percentages)

Year	Number	Mean	Median	Quartile 1	Quartile 3
1991	30	1.09	0.58	0.46	1.51
1992	31	1.03	0.56	0.35	1.41
1993	31	1.05	0.64	0.38	1.18
1994	32	1.13	0.70	0.42	1.39
1995	31	1.17	0.57	0.47	1.26
1996	33	1.31	0.70	0.53	1.43
1997	33	1.32	0.81	0.49	1.79
1998	33	1.24	0.80	0.47	1.39
1999	28	1.14	0.80	0.44	1.33
2000	32	1.22	0.86	0.51	1.48
2001	35	1.28	0.95	0.49	1.48
2002	24	1.39	0.86	0.55	1.53
2003	7	1.09	0.57	0.46	1.11
1991-1996	30-33	1.13	0.64	0.46	1.33
1997-2003	7-35	1.25	0.84	0.48	1.47
1991-2003	7-35	1.19	0.74	0.47	1.41

Note: The extreme values of TATR of 10 or more are excluded.

Paired samples test

	Paired differences							
Difference Significant	Mean	Std. Dev.	Std. Mean Error	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
(1991-96 and 1997-2003)	-0.02	0.84	0.14	-0.32	-0.27	-0.17	33.0	0.87

Table A.3: *Mean, median and quartiles values related to gross working capital cycle of sample PSEs (manufacturing), 1991-2003*

(Figures are in days)

Year	Number	Mean	Median	Quartile 1	Quartile 3
1991	73	310.50	277.73	193.18	390.42
1992	77	299.18	254.88	181.54	413.48
1993	75	310.98	285.36	208.89	394.77
1994	74	330.57	319.93	203.93	452.51
1995	75	318.64	285.51	193.90	398.50
1996	76	299.01	264.18	176.80	396.54
1997	74	296.23	275.47	178.33	410.51
1998	69	280.39	266.38	148.66	384.57
1999	73	285.70	260.55	154.73	380.47
2000	72	287.87	264.47	176.10	386.44
2001	74	270.03	215.75	161.72	381.53
2002	64	263.44	235.13	160.87	366.97
2003	29	216.22	149.30	77.45	335.95
1991-1996	73-76	311.36	277.94	191.24	401.38
1997-2003	29-74	276.84	250.62	154.98	381.18
1991-2003	29-76	294.01	266.55	176.02	388.14

Note: Excludes PSEs having GWCC 770 days or more.

Paired samples test

	Paired differences							
Difference Significant	Mean	Std. Dev.	Std. Mean Error	95% Confidence Interval of the Difference		t	df	Sig.(2-tailed)
				Lower	Upper			
(1991-96 and 1997-2003)	22.49	88.22	9.926	2.725	42.25	2.265	78	0.026

Table A.4: Mean, median and quartiles values related to gross working capital cycle of sample PSEs (services), 1991-2003

(Figures are in days)

Year	Number	Mean	Median	Quartile 1	Quartile 3
1991	6	375.07	361.46	233.31	578.29
1992	9	386.82	403.96	225.68	570.78
1993	10	280.55	277.53	128.75	393.28
1994	10	291.83	274.80	137.99	392.52
1995	11	268.81	260.05	178.99	391.83
1996	12	317.03	225.025	166.71	539.04
1997	12	280.18	254.56	126.16	318.75
1998	11	260.07	229.03	125.01	307.08
1999	10	238.72	240.83	155.78	307.49
2000	12	329.43	254.29	185.98	545.62
2001	13	294.18	194.71	138.95	436.45
2002	10	250.15	210.14	87.32	441.86
2003	5	203.83	157.73	82.73	347.99
1991-1996	6-12	314.09	280.88	180.06	419.62
1997-2003	5-13	272.72	228.51	134.9	327.36
1991-2003	5-13	291.03	252.43	159.16	403.48

Note: Excludes PSEs having GWCC 770 days or more.

Paired samples test

	Paired differences							
Difference Significant	Mean	Std. Dev.	Std. Mean Error	95% Confidence Interval of the Difference		t	df	Sig.(2-tailed)
				Lower	Upper			
(1991-96 and 1997-2003)	-38.15	275.5	104.1	-293	216.7	-0.366	6	0.727

□

The best way to escape from a problem is to solve it.

– Alan Saporta

Feature

Economic Cost of Environmental Degradation in Punjab Agriculture

Joginder Singh

A significant shift in the crop pattern in favour of rice-wheat system in Punjab has recently caused serious ecological problems. This paper attempts to quantify the effects of such estimated degradation. The problem of sustainability of paddy is a serious threat to the state agriculture, which requires diversification efforts, suitable water pricing, water harvesting technology and extension efforts.

Joginder Singh is professor, Punjab Agricultural University, Ludhiana.

The Punjab state has achieved an exemplary rate of progress in the agricultural sector, showing a rise in the agricultural production index to 340.80 in 2001-02 (1960-61 = 100). The unculturable land has been reclaimed over time and fallow land has been brought under plough, making more and more area available for cultivation. The cropping intensity also went up from 126 per cent in 1960-61 to 186 per cent in 2002-03. A significant shift in the cropping pattern has taken place.

As may be seen from table 1, rice, which occupied merely 4.80 per cent of the total cropped area in 1960-61, registered a steep rise up to 31.86 per cent in 2002-03. It was not confined only to the traditional paddy belt but spread over to the entire state wherever adequate irrigation facilities were made available. Thus the area under rice registered a compound growth rate of 12.56 per cent in the seventies, by 5.22 per cent during the next decade and only by 2.20 per cent in nineties. Similarly, the area under wheat increased from only 27.32 per cent in 1960-61 to 43.51 per cent of the total cropped area in 2000-01, beyond which increase in rather impossible. On the other hand, the area under maize, millets, sorghum, groundnut, gram, barley and lentil has fallen rapidly. However, cotton, sugarcane, pulses, rapeseed and mustard, potato and other vegetables have shown wide fluctuations in the area from year to year.

The production pattern in the Punjab state has, therefore, become predominantly a monoculture of rice-wheat rotation because of higher profitability of these crops, resulting from faster increase in the productivity and effective price support in comparison to other competing crops. The main effect of this has been a fast emergence of environmental problems such as a fall in the water table, deterioration in soil health, perpetuating pest problem, eroding bio-diversity, social problems, etc. The environmental degradation accompanying decelerating agriculture growth in generally contested

Table 1: Shift in Cropping Pattern of Punjab and Water Requirements (Area in 000 ha)

Crop	1960-61	%	1970-71	%	1980-81	%	1990-91	%	2000-01	%	2002-03	%
Rice	227	4.8	390	6.87	1183	17.49	2015	26.86	2612	32.92	2530	31.86
Maize	327	6.91	555	9.77	382	5.65	188	2.51	164	2.07	152	1.91
Bajra & Jowar	140	2.96	212	3.73	70	1.04	12	0.16	6	0.08	7	0.09
Groundnut	67	1.42	174	3.06	83	1.23	11	0.15	4	0.05	4	0.05
Cotton	446	9.43	397	6.99	648	9.58	701	9.34	474	5.97	449	5.65
Sugarcane	133	2.81	128	2.25	71	1.05	101	1.35	121	1.52	142	1.79
Kharif Pulses	32	0.68	38.5	0.68	61	0.9	72	0.96	42	0.53	28	0.35
Sesamum	8	0.17	15	0.26	17	0.25	18	0.24	19	0.24	17	0.21
Wheat	1400	29.59	2299	40.49	2812	41.58	3273	43.63	3408	42.95	3404	42.87
Barley	66	1.39	57	1	65	0.96	37	0.49	32	0.40	23	0.29
Gram	838	17.71	358	6.31	258	3.81	60	0.8	8	0.10	8	0.10
Rapeseed & mustard	106	2.24	103	1.81	146	2.16	69	0.92	55	0.69	64	0.81
Linseed	4	0.08	3	0.05	2	0.03	1	0.01	0	0.00	0	0.00
Lentil	30	0.7	13	0.3	20	0.33	10	0.19	5	0.06	4	0.05
Potato	9	0.19	17	0.3	40	0.59	23	0.31	70	0.88	71	0.89
Other vegetables	23	0.49	23	0.41	24	0.35	31	0.41	46	0.58	74	0.93
Fruits	42	0.89	50	0.88	29	0.43	69	0.92	34	0.43	40	0.50
Fodder & others	859	18.15	866	15.25	959	14.18	827	11.02	657	8.28	924	11.64
Total cultivated area	3757		4053		4191		4218		4264		4268	
Total crop area	4732	100	5678	100	6763	100	7502	100	7935	100	7941	100
Water requirement index		**100.00**		**117.74**		**146.88**		**168.85**		**175.91**		**175.42**

% means the area under the crop as per cent of Total cropped area.

Area under vegetables, fodder and other crops is not shown crop-wise due to paucity of split up of such data.

Fruits are perennial and the figures pertaining to area under fruits are also not much reliable.

Water requirement index was worked out on the basis of per crop evapo-transpiration of different crops.

to be a second and third generation problem. Therefore, the economic evaluation of social cost is a cumbersome process. An effort has been made in this paper to assess the extent of deterioration in the natural factors and enhancement of cost due to the factors such as deepening of water table, soil fertility and pest resistance.

Deceleration in crop productivity growth

Punjab, being located at the foot of the Himalayan range has the advantage of rich underground and surface flowing water. The farmers took advantage of the situation and brought about revolutionary improvement in food production, but this has brought up the issue of the sustainability of the existing crop system. Recently, the growth in average yield of rice and wheat has shown a dampening trend in spite of increase in the input use. Nevertheless, wheat being the traditional crop of the state is still increasing at the rate of 1.99 per cent per annum (Table 2). There is ample evidence to indicate that the Total Factor Productivity of these crops has gone down mainly due to ecological problems pertaining to depletion of soil fertility, water availability and pest resistance etc. (Singh & Hossain, 2002).

Methodology

In order to capture the extent of degradation of environmental factors, data from different sources was collected. Water resource and its use was examined with

the help of data on water table in the month of June (pre-monsoon period) and October (post-monsoon period), available for 13 out of 17 districts from 1981 to 2001 from the Department of Agriculture, Punjab. The data regarding overtime use of major and micro soil nutrients and pesticides were also taken from secondary sources. To supplement it, the primary data was collected by carrying out a survey of 19 villages selected from 19 blocks representing different agro-climatic conditions of the State. A sample of 10-11 farmers in each village was taken at random from different farm size groups. Thus, in all, 193 farmers were interviewed and the data on schedules prepared for this purpose were collected. Farmers' perceptions about the use of water and soil resources, pest problems, bio-diversity and use of by-products were recorded. These costs were translated into economic values on the basis of secondary data and farmers' perceptions.

Table 2: CGR of Average Yield of different crop in Punjab

Crop	Period I 1970-71 to 80-81	Period II 1980-81 to 90-91	Period III 1990-91
Rice	4.67	1.17	0.43
Bajra	0.47	–2.18	–2.08
Maize	0.36	–0.72	3.42
Wheat	2.27	2.92	1.99
Barley	4.92	5.72	2.24
Gram	–2.14	4.13	2.25
Groundnut	0.03	–0.90	–0.57
Rapeseed & mustard	0.01	4.85	1.00
Sugarcane	3.09	0.37	0.26
Cotton	–1.56	7.60	–5.44

Results & Discussion

Evidence of Depleting Water Resource

The water table measured from a sample of wells in different blocks of 13 districts for the past two decades has indicated a trend of overall decline. The three major agro-climatic areas present different pictures of water table.

In the semi-hilly belt (represented by Gurdaspur, Hoshiarpur and Ropar districts) the water table has shown an insignificant rise/fall over the past two decades. Since the water table is deep and soil is rocky, pumping out water is relatively uneconomical. Therefore, although there is a trend of increasing use of water in this area, the problem of a decline in the water table has not been not aggravated in this part of the state.

Table 2: Linear Trend of rise/fall in Water-Table in metres, 1981-2001

District/ Zone	Month	Intercept	Reg. Coefficient	R^2
Gurdaspur	June	6.6220	0.0269	0.1464
	October	5.8149	–0.0001	0.0000
Ropar	June	6.1912	0.1092	0.3939
	October	5.5124	0.0597	0.1721
Hoshiarpur-1	June	6.7370	–0.0366	0.0551
	October	6.0808	–0.943	0.2520
Hoshiarpur-2	June	16.1340	–0.1238	0.3729
	October	14.8420	0.0846	0.0962
Amritsar	June	4.7534	0.1752	0.8482
	October	3.6566	0.1785	0.7782
Kapurthala	June	4.7004	0.1664	0.7047
	October	3.6566	0.1785	0.7782
Jalandhar	June	6.0642	0.2370	0.8148
	October	5.3083	0.2118	0.5675
Patiala (Nabha)	June	4.4813	0.3185	0.8995
	October	3.62761	0.3508	0.9119
Sangrur (Lehra Gaga)	June	3.8386	0.1571	0.7870
	October	3.3087	0.1819	0.6001
Ludhiana	June	6.5282	0.1463	0.6411
	October	6.3097	0.1081	0.6186
Sangrur (Barnala)	June	6.6450	0.4288	0.9738
	October	6.6862	0.4391	0.9572
Patiala (Patran)	June	6.9480	0.3265	0.7798
	October	6.8066	0.3102	0.7824
Faridkot	June	2.6994	0.1218	0.7805
	October	2.2005	0.1332	0.8864
Mansa	June	5.9720	–0.0949	0.656
	October	5.5900	–0.0837	0.4243
Bathinda	June	11.7320	–0.2244	0.8764
	October	11.2680	–0.2016	0.8181
Ferozpur	June	6.4118	–0.1806	0.6598
	October	6.0410	–0.1645	0.9359
Semi-hilly area	June	18.3690	–0.0443	0.0367
	October	14.2030	–0.0667	0.0880
Central belt	June	5.5940	0.2467	0.9156
	October	5.0852	0.2401	0.8372
South-western belt	June	6.7518	–0.0752	0.6352
	October	6.5948	–0.0609	0.4659

Based on the district average if data collected by Department of Agriculture, Punjab.

In the central belt, which has mainly paddy-wheat cropping system, the water table in 1981 ranged between 3 and 7 metres, but it is declining at a fast rate i.e. 11-15 cm in Ludhiana, 16-18 cm in Sangrur (Lehra Gaga), Kapurthala and Amritsar, 21-24 cm in Jalandhar, 31-35 cm in Patiala and 43-44 cm in Sangrur (Barnala). On an average, the central belt had a 5-6 metre water table in 1981 and showed a fall at the rate of 24-25 cm per annum. This belt has high potential for agricultural production but due to fast depletion of the water resource it is facing the problem of sustainability of existing cropping systems.

The cotton belt comprising almost one-fourth of the cultivated area of the state has deep and brackish water. The Bathinda district, with a 11-12 metre water depth in 1981 is continuously showing a rise of 20-22 cm per year, forcing the farmers to shift from cotton to rice cultivation. Ferozpur and Mansa districts observed a rise in the water table by 16-18 cm and 8-9 cm/year respectively. The Faridkot district, where the water table had already risen, is now receding by 12-13 cm/year.

The fall in the water table in the state, in general, can be attributed mainly to an increase in paddy area from 1180 thousand ha in 1980-81 to 2487 thousand ha in 2001-02. The rainfall, an exogenous variable, did help to improve the position of underground water resource but it was exploited faster than its rejuvenation. The situation is clear from the following function fitted in the state data for the past two decades.

$$W = 1.2980\ Ap^{0.2593**} Rf^{0.2532**} \qquad (R2 = 0.7473**)$$

**indicates the significance at 0.01 level.

The level of water table (W) was determined by paddy area (Ap) and rainfall (Rf) to the tune of 75 per cent. The rainfall helped to improve the situation significantly but paddy area alone depleted it equally, resulting in deterioration of water balance situation.

Due to fall in the water table, particularly in the central belt,

(a) The cost of pumping out water has increased, as the power required for lifting water from a deeper level is much higher.

(b) deepening of tubewell bores has to be done and the centrifugal pumps are being replaced by submersible pumps.

(c) more tubewells are being installed. The electricity is in short supply and diesel pumps as a supplementary source of power are being increasingly used, accelerating the cost of production still further.

A survey of 193 farms in Punjab indicated that during the period of 10 years (1986-1995), 15.70 per cent tubewells were deepened after an average period of 11.9 years of installation (Table 3). The additional cost per deepened tubewell amounted to Rs 4044. During the next 5 years (1996-2000) another 21.5 per cent were deepened incurring an additional cost of Rs 6521. Surprisingly, during the next one year (2001) 13.31 per cent tubewells had to be deepened. The average cost per deepened tubewell turned out to Rs 7612 over the initial cost of Rs 10919, incurred about 12 years ago. Further, the sample of 193 farmers had 293 electric tubewells, which means that an average farmer had almost 1.5 tubewells. The additional depth of 17.8 feet per tubewell was made to the original average depth of 95.7 feet.

Table 3: Deepening of tubewells by the sample farmers in Punjab.

Period	Deepened TW (no.)	%	Year after installation	Average initial cost (Rs.)	Average added cost (Rs.)	Depth origin (ft)	Additional depth (ft)
1985-95 (10 yrs)	46	15.70	11.90	4404	818	95.7	17.8
1996-2000 (5 yrs)	63	21.50	11.70	9789	6521	108.8	18.3
2001 (1 yrs)	39	13.31	12.10	10919	7612	120.8	19.1
Total	148						

Source: Based on Survey data collected by Deptt. of Economics & Sociology, PAU

Higher Power Requirements

The horse power (HP) required to pump out water from the deeper surface also went up simultaneously. On the whole, the average HP use was 5.03 which increased to 5.64 per tubewell showing an increase of 12 per cent over a period of 12 years (Table 4). 22% tubewells were of 3 HP, while one-fourth moved to 5 HP. Nearly 55 per cent started with 5 HP, while one- fifth of them changed to 7.5 and 10 H.P. Similarly, 1.85 per cent tubewells having 7.5 HP enhanced the HP to 10.

Additional cost

The cost per deepend tubewell during 2001 came out to Rs 7612 over the initial installation cost of Rs 10919, which was incurred about 12 years ago. Thus, the annual burden on State agriculture (i.e. Rs 634/ tubewell and 870,000 number of electric tubewells) is estimated to be Rs 551.6 million.

To split the cost for paddy and wheat, the area

under these crops, number of irrigations required for each crop and intensity of irrigation were considered. The per hectare cost of deepening of tubewells (in terms of labour, higher HP and connection fee etc.) worked out as Rs 450.20 which may be split into Rs 292.63 (65 per cent of water use) for rice and Rs 90.04 (20 per cent of water use) for wheat crop per year. The additional annual cost of diesel and electricity, repair etc. was relatively much higher in case of paddy due to critical water scarcity reason and thus amounted to Rs 35 and Rs 4 per hectare for paddy and wheat respectively.

Table 4: B.H.P. of Electric motor before and after deepening of tubewells in Punjab, 2001

B.H.P. of Tubewells Deepened				No. of Tube-wells	Per cent Tube-wells
Before	Weighted average	After	Weighted average		
0		3		4	1.48
0	0	5	4.11	5	1.85
3		3		46	16.97
3	3	5	3.47	14	5.17
5		5		120	44.28
5	5	7.5	5.55	27	9.96
5		10		3	1.11
7.5		7.5		29	10.70
7.5	7.5	10	7.87	5	1.85
10	10	10	10	18	6.64
Overall	5.03		5.64	271	100.00

Source: Based on Survey data collected by Deptt. of Economics & Sociology, PAU

Deterioration in Soil Health

Depletion of soil fertility in terms of major soil nutrients such as Nitrogen, Phosphorus & Potash and micro-nutrients like Zinc, Iron, Manganese, have been commonly observed. The farmers are familiar with the use of Nitrogen & Phosphorous for wheat and paddy crops, but over time use has gone up by 53.30 Kg/ha and 7.20 Kg/ha in case of paddy and 51.45 Kg/ha and 16.88 Kg/ha in case of wheat crop respectively (as may be viewed in Table 5). The use of FYM per hectare declined due to its less availability resulting from expansion in areas faster than livestock number. The use of potash also declined over time because of lack of yield response to potash. The use of micro-nutrients particularly zinc, iron and manganese in case of paddy crop has gone up considerably. As may be viewed from the table, Zinc sulfate and Iron sulfate application per hectare increased by 13.70 kg and 1.60 kg respectively. No such deficiency symptoms were observed in wheat crop.

The results get further support from the secondary data presented in Appendix-I showing increasing symptoms of major and micro-nutrients. The data taken from 'Cost of cultivation scheme' was also in line with the above discussion. The additional burden due to deteriorating health thus can be estimated to Rs 913.95/ha on paddy and 874.15/ha in case of wheat crop at 2001 prices during the past one decade.

The change in soil texture and structure, effects of paddy straw burning and declining organic matter in the soil also need to be quantified in terms of their economic effect on the crop.

Table 5: Fertilizer use by sample farmers in Punjab, 1991 & 2001

(per ha)

Year	FYM (Qtls.)	N (Kgs)	P (Kgs)	K (Kgs)	Zn SO4 (Kgs)	Fe SO4 (Kgs)	Cost at 2001 prices (Rs/ha)
A. Paddy crop							
1991	100.00	97.90	24.73	2.00	9.00	2.25	1824.75
2001	73.73	151.20	31.93	1.00	22.70	3.85	2738.70
Change over time	–26.28	+53.30	+7.20	–1.00	+13.70	+1.60	+913.95
B. Wheat crop							
1991	29.50	106.45	51.33	3.33	0.00	0.00	2209.45
2001	21.95	157.90	68.20	2.30	0.00	0.00	3083.60
Change over time	–7.55	+51.45	+16.88	–1.03			+874.15

Source: Based on Survey data collected by Deptt. of Economics & Sociology, PAU

Use of Pesticides

As a consequence of monoculture, the pest resistance of some of the weeds, insect-pests and diseases has been developed. The area covered under weedicide spray was about 68 per cent and 72 per cent in case of paddy and wheat during 1991, which increased to 95 per cent and 93 per cent respectively during the past one decade. Apart from this, the dose of weedicides increased and new type of weedicides increased and new type of weedicides were introduced which together raised the cost by Rs 97.69/ha in case of paddy and Rs 697.04/ha in case of wheat crop. In a similar fashion, the cost of other pesticides to control various pests during the past decade went up by Rs 614.65 and Rs 109.74/ha in case of paddy and wheat crop respectively. Thus the total cost of pesticides at 2001 prices have escalated by Rs 876.53/ha in case of paddy crop and Rs 949.24/ha in case of wheat crop during the period of one decade. In other words, annual cost increase can be estimated at Rs 87.65/ha and Rs 94.92/ha in case of paddy and wheat respectively.

Table 6: Sprays given against weeds and insect-pests in paddy and expenditure incurred thereon by the sample farmers, Punjab, 2001

(per ha)

Year	Number of Spray against		Expenses (Rs.) on Sprays against		Cost at 2001 prices
	Weeds	Insect-Pests	Weeds	Insect-Pests	Rs/ha
Paddy Crop					
1991	0.68	0.36	271.26	138.98	247.05
2001	0.95	1.61	368.95	753.63	1122.58
Change over time	+0.27	+1.25	+97.69	+614.65	+876.53
Wheat Crop					
1991	0.72	0.04	347.61	7.48	212.63
2001	0.93	0.32	1044.65	117.22	1161.87
Change over time	+0.21	+0.28	+697.04	+109.74	+949.24

Source: Based on Survey data collected by Deptt. of Economics & Sociology, PAU

Farmers' Perceptions on Environmental effects

The education and awareness of farmers about the consequence of degrading the ecological balance due to the rice-wheat system, are essential to rectifying the problem. All the 193 farmers were aware of the decline in water table due to excessive use of the water resource in state agriculture (Table 7). About 55 per cent farmers reported an increase in air pollution owing to burning of paddy straw. The increase in the incidence of crop diseases was stated by 66.84 per cent and decline in soil fertility by 64.77 per cent respondent farmers. As many as 41.45 per cent farmers expressed concern of economic loss due to increase in cost of cultivation, as a result of the environmental factors. Only 6.22 per cent farmers were aware of pest resistance and elimination of friendly insects. The human loss in the process of deepening of wells due to poisonous gases was noted with serious concern by 2.07 per cent farmers.

Table 7: Farmer's perceptions of bad effects of Paddy-wheat crop rotation in Punjab, 2001

Farmer's Perception	No. of farmers	Percentage of farmers
Changes in level of water table	193	100.00
Pollution of environment due to burning of straw	106	54.92
Increase in diseases	129	66.84
Decrease in Soil fertility	125	64.77
Increase in cost of cultivation	80	41.45
Developing pest resistance and elimination of friendly insects	12	6.22
Death of people due to deepening of wells	4	2.07

Source: Based on Survey data collected by Deptt. of Economics & Sociology, PAU

Suggestion by farmers to rationalize water use

The suggestions given by the farmers to check lowering of water table in Punjab are presented in Table 8. A vast majority of farmers were of the view that alternative crop enterprises should be developed (92.93%) through genetic improvement (89.64%) and price policy (43%), such that their economics are comparable with paddy crop. The early transplanting of paddy should be avoided to check the declining water table in the state, said 41.45 per cent farmers. Even 30.57 per cent of the view that government should ban early transplanting. About 34.20 per cent farmers suggested streamlining the canal water to minimize drawl of underground water. Yet another 39.90 per cent farmers suggested that farmers be made familiar with new techniques in agriculture developed by Punjab Agricultural University (PAU) and 8.81 of them suggested that farmers should adhere to PAU recommendations to keep check on resource degradation.

Overall cost

On the basis of analysis of data collected from farmers by taking into account the three major

parameters, i.e. water, soil and pesticide use, the increase in per hectare cost was estimated at Rs 506.68 in case of paddy and Rs 276.38 in case of wheat crop (Table 9). The water resource alone accounted for about 57.75 per cent and 32.58 per cent of it in case of paddy and wheat respectively. Each of the soil health replenishment and pest resistance were responsible for an additional cost of Rs 87.95 for each crop. Therefore, every year cost escalation due to environmental factors, worked out to Rs 7.20/qtl of paddy and Rs 4.30/qtl of wheat. The growth in productivity by 0.43 per cent in case of paddy compensates by Rs. 2.30/qtl showing a net loss of Rs. 7.44/qtl. The growth in yield of wheat still maintained at 1.99 per cent mitigates the environmental cost of the crop. The remarkable and continuous technological improvements in wheat crop and less environmental losses have largely been responsible for maintaining the tempo of wheat crop in the state. Paddy crop, however, is causing serious economic and environmental sustainability not only for itself but also for other crops in the area.

Table 8: Suggestions of farmers on how to check lowering of water table in Punjab, 2001

Suggestions	No. of farmers	% farmers
Shift to subsidiary occupations	178	92.23
Avoid early transplanting of paddy	80	41.45
Adhere to University recommendations	17	8.81
Govt. should fix appropriate price and ensure timely marketing of sugarcane pulses and sunflower	83	43.00
Make available more canal water and collect water in drains	66	34.20
Govt. should ban early transplanting and restrict purchase of early maturing varieties of paddy	59	30.57
PAU should evolve disease free HYVs of other crops ensuring returns higher than that of paddy	173	89.64
Farmers should be made familiar with new techniques in agriculture being developed at University level	77	39.90

Source: Based on Survey data collected by Deptt. of Economics & Sociology, PAU

Therefore, there is a strong need to have suitable water pricing, water saving and water harvesting technologies so that the demand for water is reduced. Currently it is highly subsidized. Appropriate price policy and export market infrastructure can also bring about diversification of agriculture. Lack of knowledge on the part of farmers calls for this education, extension and training, so that the environmental effects could be minimized through certain agronomic practices.

Table 9: Environmental cost of paddy and wheat per annum (Rs/ha)

Item	Paddy	%	Wheat	%
Deepening of Tubewell	292.63	57.75	90.04	32.58
Additional running cost of higher HP motor including electricity, diesel etc.	35.00	6.91	4.00	1.45
Major & micro nutrients				
Pesticides	87.65	17.30	94.92	34.34
Total	506.68	100.00	276.38	100.00

Summary

A significant shift in crop pattern in favour of the rice-wheat system in the high potential agriculture state of Punjab has recently caused serious ecological problems. This paper has attempted to quantify the effects of such estimated degradation. The fall in water table adding to the cost of deepening of tubewells, fall in H.P. requirement and high energy inputs accounted for per hectare additional cost of Rs 327.63 and Rs 94.04 per annum in case of paddy and wheat respectively. Similarly, due to the nutrient exhaustive nature of this crop system, major and micro nutrient deficiencies have been increasingly noticed and developing pest resistance required higher use of pesticides. Thus on the whole, the cost of production of paddy and wheat is spearheading by Rs 9.74 and Rs 6.14 per quintal, which is compensated partly by an increase in paddy yield and fully by wheat yield. The problem of sustainability of paddy is a serious threat to the state agriculture, which required diversification efforts, suitable water pricing, water harvesting technology and serious extension efforts.

References

Singh, Joginder, G.S. Dhaliwal & N.S. Randhawa (1997), "Changing Scenario of Punjab Agriculture – An Ecological Perspective", CRRID. Chandigarh.

Singh, Joginder and D.K. Grover (1996), "Punjab Rural Water Supply and Sanitation Project" – A Socio-economic Survey report submitted to the World Bank", Report, PAU Ludhiana.

Joginder Singh and Hossain M. (2002), "Total factor productivity analysis and its components in a high-potential rice-wheat system: a case study of the Indian Punjab", pp. 409-417 in Sombilla M, Hossain M and Hardy B, editors. Developments in the Asian rice economy. Proceedings of the International Workshop on Medium- and Long-Term Prospects of Rice Supply and Demand in the 21st Century, 3-5 December 2001, Los Banos, Philippines: International Rich Research Institute, 436 p.

Appendix 1

Use of Agro-Chemicals in Punjab

Year	Micro-nutrient use for paddy crop(t)			Fertilizers (000 tonnes)	Pesticides TGM (tonnes)
	Zinc Sulphate	Ferrous Sulphate	Manganese Sulphate		
1981	5042			116.0	3200
1985	9980			153.0	4800
1990	8879	284		162.6	6500
1995	11315	672		166.7	7200
2000	23340	1360	80	168.3	7005
2001	27870	2400	220	177.2	7200
2002	38000	3400	300	186.9	6400

□

All organisations do change when put under sufficient pressure. This pressure must be either external to the organization or the result of very strong leadership.

– Bruce Henderso

Feature

Composite Development Index for Measurement of Agricultural Progressiveness

C. Prasad, S.P. Singh & Anil Rai

In this study the author has developed an index for the measurement of agricultural progressiveness of different states of India, which can be utilized by scientists and development workers in so many ways. The data of 30 indicators have been used for 25 states of the country to develop the Composite Development Index to measure agricultural progressiveness. Punjab followed by Haryana, turned out to be agriculturally most developed states, whereas, Jammu and Kashmir and North-Eastern Hill states were agriculturally least developed states in the country.

C. Prasad is the former Deputy Director General (Ag. Extension) ICAR; S.P. Singh is former Principal Scientist, ICAR & Director (Programmes) VARDAN, New Delhi; and Anil Rai is Senior Scientist, Indian Agricultural Statistics Research Institute, New Delhi.

Agriculture, the backbone of the national economy, constitutes about 25 per cent of the total Gross Domestic Product (GDP) of the country. The agricultural growth in the country during the last three decades of the preceding century has been quite phenomenal and has appropriately been termed as the 'Green Revolution' because of which the country has moved from a hand to mouth economy to a surplus country that is now able to provide food assistance to some needy countries as well. Besides this, the country is also highly productive in the case of fruits and vegetables, milk, meat and eggs. Such commendable achievements are the result of systematic planning, research and extension, and the sincere efforts of the toiling farmers. However, the critical analysis of trends in agricultural development in the country clearly evince the harsh reality of inter-state imbalances existing earlier, which in fact have widened in the Green Revolution era and are still on the increase. The development so far has been skewed in favour of economic gains. Thus, social development has been left high and dry. This should be a matter of great concern for the development planners and strategists, both government and non-government.

During the post-independence era, there have been concerted efforts in the country for balanced development through 'Five Year Plan' approach. In the plans completed so far as well as in the present plan viz. Tenth Five Year Plan, the most important concern is the narrowing of the development gap and the enhancement of the quality of life of the general masses by providing the basic necessities of life as well as effecting improvement in their social and economic well-being.

The 'Green Revolution' in the agricultural sector

and commendable progress on the industrial front have certainly increased the production in agriculture and manufactured goods, but there is enough evidence which suggests that there has been further widening of already existing socio-economic gap the over years. The improvement in quality of life of the poor has been appreciable in limited areas but has almost remained static in major areas. Inspite of all possible concerted efforts in different plans, wide variations in growth rate exist in different states of the country due primarily to considerable disparities in adaphic, socio-economic and cultural conditions besides slow development in infrastructural facilities. The regional imbalances both within state and between states are the result of variations in the levels of development of agriculture accompanied by equally sharp variations in infrastructure facilities.

The differential agricultural development in various states in the country has been a great concern to the planners, policy makers and scientists. Therefore, continuous efforts have been made to measure the levels of development of various states in order to classify them and to know where a given state stands in relation to others at a given point of time. This will also help for understanding the parameters responsible for poor development. This understanding may be of help in planning for the development of such lesser developed states and promoting strategy for developed ones.

In proceeding years, several approaches have been used to quantify the gap in agricultural progressiveness of different regions and/or states. In most of these studies either one indicator or a few indicators were used for the measurement of agricultural progressiveness. It is, however, realized that none of these approaches took a holistic view of the measurement of agricultural progressiveness of the states. An attempt has been made in this study to develop a composite index of agricultural development for the 25 states of India which may form a basis of comparison among them. The basic objectives of development of index is to select and compare agriculturally less developed states with regard to various dimensions of agricultural development including management.

The effort has been made in this study to develop a Comprehensive Development Index so that different states could be properly evaluated based on common parameters, to get an overall picture of the agricultural development situation in various states of India. This understanding on the stratification of states will help various studies especially those dealing with management and its various processes including research-extension linkages.

Research-Extension Linkage Study

Background & Objectives

Functional linkage or integration between or among systems/sub-systems is an universal and common phenomenon in any subject-matter area and organization, be that agriculture or industry. But in practice it is a very difficult proposition—smooth working, proper linkages and success in any organization are an uphill task. In the field of agriculture, linkage is all the more difficult in view of its inter-disciplinary nature, multi-institutional approach and working, and applied in its content and complexity. The main partners in this process are: (1) farm scientists, (2) policy-makers and administrators, (3) extension agents, (4) input agencies, (5) the farmers (6) NGOs and (7) pure social scientists. This subject requires not only proper organizational set-up and policy directions for integration purposes, but also a human handling and approach with a deeper understanding of the theory and practice of cooperation, team work and functional linkages. The process is not only a two-way communication, but also a multi-dimensional one.

In the field of agriculture, linkage is difficult in view of its inter-disciplinary nature, multi-institutional approach and working.

In all projects and programmes almost everywhere, there is, by and large, an in-built mechanism for linkage and coordination - many committees and scientific consortiums are formed to achieve integrated working and attain synergistic effects. In practice, though, they partially function and, therefore, the achievements are also proportionally inadequate and limited. Owing to this very phenomenon, linkage always remains a topic of common interest and discussion and in reality a baffling subject - the weakest link in the agricultural organizations and agricultural development system(s).

In view of the importance of linkage mechanism for effective functioning of research and extension systems, Indian Council of Agricultural Research (ICAR) sanctioned a project entitled "Dynamics of Research - Extension Linkages for strong and sustained farm transfer of technology system : Evolving a management Model" to "Voluntary Action for Research Development and Networking (VARDAN)" a non-government organization (NGO) under the National Agricultural Technology Project (NATP) of the World Bank-funded programme.

The main objectives of the research project were as under:

- Understanding the major States on the scale of agricultural progressiveness as a prelude to assessing the research-extension linkages;
- Through a comprehensive research/literature review, conceptualizing the linkage paradigm with focus on management processes contributing to research-extension linkages;
- Assessing the organizational structure, its effectiveness and efficiency as a basis to research-extension linkage study in the selected states;
- Measuring the research-extension linkages status of the selected states and evolving an appropriate Research-Extension linkage model for the Centre and the states;
- Developing a manual on research-extension-education and clientele linkages as an operational guide; and
- Raising management policy issues for strengthening the overall efficiency and effectiveness including the management process contributing to research-extension linkages.

Progressiveness Study - a Foundation for Linkage Study

Research-Extension Linkage (REL) is one of the basic and important processes of agricultural management system(s). The national and international R&D agencies have been vocal about its need, importance and scope, but all said and done, it has been recognized always as the weak link in the chain of development process. It has been the most difficult management task and being a social management process, its intricacies are less known to farm scientists and, therefore, REL is poorly practiced. It is essential, therefore, that this component of agricultural management is thoroughly studied and its critical factors of operation and practices are brought to the fore before the organization and the management personnel and administrators.

From the objectives of the Project, it would be observed that the states of the country were to be broadly categorized into agriculturally highly developed, moderately developed and least developed, and a few from each category were to be further studied for linkages status and based on that, a model was to be proposed for effective functioning of the national agricultural research and extension systems. However, literature reveals that there is lack of a comprehensive procedure to study the agricultural progressiveness of all the states for in-depth study of linkage mechanisms. Keeping this in view, a detailed study for the development of agricultural progressiveness index of 25 states of India was undertaken for which requisite data were available. This study of the development of the *Comprehensive Progressiveness Index* is thus, a foundation for this R-E-L study.

Earlier Studies

The published literature on the earlier efforts to measure the agricultural development of different states are not many, though lots of attempts have been made to measure economic development. It was thought that unless there is an idea of the magnitude of the problem, no proper and effective measure can be initiated to achieve the objective of balanced regional development. Therefore, the Planning Commission took the lead by appointing a Working Group popularly known as 'Pande Committee' in 1968 to go into the question of identification of backward areas. It suggested six criteria for the identification of backward states viz. total per capita income, per capita income from industry and mining, number of workers in registered factories, per capita annual consumption of electricity, length of surfaced roads in relation to population and area; and railway mileage in relation to population and area. The Committee identified the states of Andhra Pradesh, Assam, Bihar, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Nagaland, Orissa, Rajasthan and Uttar Pradesh and all union territories except Delhi., Chandigarh and Pondichery as industrially backward states. On the basis of the above mentioned six indicators the committee identified 238 districts in India as industrially backward.

To examine the backward area programmes in depth, the Planning Commission set up a Committee headed by Shri B. Sivaraman in 1978, known as the National Committee on the Development of Backward Areas. It adopted the problem area approach for identification of backward areas and identified six types of problem areas as chronically drought-prone, desert, tribal, hill, chronically flood-affected and coastal areas affected by salinity. The committee referred to the concept of S. Chakravarty Working Group which studied the problem by using three methods viz. simple ranking, indices and principal component analysis and identified 164, 206 and 181 districts as backward districts by these three methods respectively, in which 16 districts were common.

It is worth mentioning here the pioneering study of levels of regional development at the district level by

Ashok Mitra based on 1961 Census data using large number of indicators. The study divided the then 327 districts of the country into four levels of development relying on simple ranking method. The study, apart from producing useful data, brought out the association between different indicators and the levels of development. Some attempts were made to develop the index of economic development. Bennet (1951) constructed a non-monitory index of development to focus the attention of international disparities. The Census Commission of India has classified all the districts of the country into four categories (I to IV) in the ascending order of their development based on subjective weighting (Dasgupta, 1971). He classified 294 districts of the country according to their degree of development as given in the 1961 Census data. Rao (1973) used six indicators in constructing an index of development of various regions of India. He developed a composite index of development based on co-variation in various indicators of development. Mukharjee (1980) had also worked in this area. Pal (1972) used the method of principal component analysis to study the regional disparities in India. Rao (1972) had looked into the question in a number of studies using the technique of principal component analysis. Her studies revealed a general decline in regional disparities.

Recently a study, "District - Level Deprivation in the New Millennium" on India's most backward districts was conducted by Bibak Debroy of the Rajeev Gandhi Institute of Contemporary Studies and Laveesh Bhandari of Indicus Analytics (Aiyar, 2003). The study had identified 69 most backward districts using a wide resource base of data and benchmarked it on attainment of the Millennium Development Goals (set by the UNDP) across six measures of socio-economic measures; viz. poverty, hunger, literacy, immunization, infant mortality and elementary enrolment. Most of the districts identified in this study regularly figure in reports of different Committees during the last four decades. It gives an impression that this region has been caught in a time wrap. Joshi (1989) had also studied the problem of inter-state disparities in infrastructure and economic development. He found out that the disparities were very substantial in both the variables, but there was slight reduction in the disparities in infrastructure as per Government policy of development in background areas.

Alagh and Bhalla (1979a) had classified various districts of the country into high, medium and low productivity districts based on the value of agricultural output per hectare. They also classified the districts into high, medium, low and decelerating growth districts based on annual growth rate. Vijayaragavan (1987a) developed a composite agricultural development index to categorize the Indian states based on their degree of development. He considered eight agricultural development parameters for the construction of index. In this index, value ranged between zero to one, the states with the index near zero were regarded as progressive and near one least progressive. The results of both the above scientists suggested Punjab as the most agriculturally progressive state followed closely by Haryana, whereas Madhya Pradesh and Rajasthan came out as the least progressive.

About This Study

The Green Revolution in the agricultural sector has certainly increased the total agricultural production, but there is no indication that these have been able to reduce substantially the state/regional inequalities and poverty. It has been the continuous endeavour of the policy makers, scientists and the planners to measure the level of development in different regions of the country to identify their relative position and to identify the possible reason for it. The main objective of this progressiveness study is to make a comparative assessment of present agricultural development in different states of India so that the states could be categorized properly based on the multi-factor indices. In a large-sized federal country like India, there are likely to exist wide disparities in the level of agricultural development and the rate of growth in various states of the country. Keeping this premise in view this study was conducted.

The Green Revolution certainly increased the total agricultural production, but there is no indication to reduce substantially the state/regional inequalities and poverty.

In the present study, an attempt has been made to quantify the agricultural development of different states of the country by computing the composite development index for each state based on the variables related to agricultural development especially in the context of foodgrain production. The specific objective of the study was to estimate the composite indices of agricultural development for each state and to categorize the states of India based on the computed composite index.

Prosperity of a country depends upon the development of agriculture and industry, and infrastructural support is the pre-requisite for the development. Social development, by definition, is not a pre-determined state but it is a continuous process of improvement of the

level of living, whereas, the infrastructure plays an important role in the economic development of a country in general and a developing nation in particular. In India, the vast geographical dispersion of economic activities and the high degree of variability of infrastructural facilities over the expanse, warrants the availability of a matrix of development of infrastructure over different states. Here it is important to mention what the infrastructural sector was considered for this study. There are no definite guidelines in this regard. Usually, economic infrastructure refers to many activities such as public utilities including power, telecommunications, water supply etc. or public works like roads and major dams or public transport etc. The level of infrastructural development in a country is a crucial factor determining the pace and diversity of agricultural growth. The link between development and infrastructure is not a once for all affair, but a continuous process and this process in development has to be preceded, accompanied and followed by progress in infrastructure for accelerated economic development. Keeping in view the nature of the infrastructural facilities required for agriculture and availability of published data, we have focused essentially on four major infrastructural facilities i.e. energy, transport, irrigation and finance in this study. Besides these, communication, education and health, being essential parameters, have also been included.

Prosperity of a country depends upon the development of agriculture and industry, and infrastructural support is the pre-requisite for the development.

Method of Analysis

The development of states is a multi-dimensional process. Its impact cannot be captured fully by any single variable. The variables may be related to socio-economic development, agricultural development or industrial development or related to any other sector of economic development. In this study, all the available variables related to agricultural development have been considered to work out the 'Agricultural Development Index' of various states of the country.

The states have been considered as the unit of analysis since the data required for analysis were generally available at the state level only. The 25 states of the country have been included in this analysis; Union Territories have been excluded from this study in absence of basic data on agricultural development. Further, newly created states viz. Uttaranchal, Chhatisgarh and Jharkhand have also not been considered separately since data for these three States were also not available. And the data for Uttar Pradesh, Madhya Pradesh and Bihar are for undivided States. The data used for this study has been mainly taken from publications of Directorates of Economics & Statistics, Ministry of Agriculture, Govt. of India. The study utilizes the data on various types of agricultural indicators such as net area irrigated (in 000 ha), area under green manure (in Lakh ha), percentage of population below poverty line, consumption of fertilizer and pesticides (in t) etc. The data relating to different parameters was available in different units, hence the data was converted into smallest basic units and standardized on a common base. The statistical methodology adopted for calculating the Composite Agricultural Development Index is given as under.

Estimation of Composite Development Index

A set of n points represents states 1,2,...,n for a group of K indicators 1,2,...,K. This can be represented by a matrix $[X_{ij}]$; i = 1,2,...,n and j = 1,2,...,K. as the development indicators included in the analysis are in different units of measurement and since our object is to arrive at a single composite index relating to the dimension in question. There is a need for standardization of the indicators. Hence, the indicators are standardized as shown below:

$$Z_{ij} = \frac{X_{ij} - \bar{X}_j}{s_j}$$

where $= s_j^2 = \sum_i^n (X_{ij} - \bar{X}_j)^2$

$$\bar{X}_j = \sum_i^n \frac{X_{ij}}{n} \qquad (i = 1,2,...,n)$$

$$(j = 1,2,...,K)$$

$[Z_{ij}]$ denotes the matrix of standardized indicators. The best state for each indicator (with maximum/minimum standardized value depending upon the direction of the indicator) is identified and from this the deviations of the value for each state are taken for all indicators in the following manner:

$$C_i = \left\{ \sum_{j=1}^{k} (Z_{ij} - Z_{0j})^2 \right\}^{1/2}$$

where Z_{oj} is the standardized value of the jth indicator of the best state and C_i denotes the pattern of development of ith state. The pattern of development is useful in identifying the states which serve as 'models' and it also helps in fixing the potential target of each indicator for a

given state. The composite index of development is obtained through the following formula :

$$D_i = \frac{C_i}{C}$$

Where $C = \bar{C} + 2s$, $\bar{C} = \sum_{i=1}^{n} \frac{C_i}{n}$,

and $s = \left\{ \sum_{i=1}^{n} \frac{(C_i - \bar{C})^2}{n} \right\}$

The value of composite index is non-negative and it lies between 0 and 1. The value of index closer to zero indicates the higher level of development while the value of index closer to1 indicates the lower level of development.

Indicators of Development

The indices of level of development in 25 states of the country have been obtained by utilising the data on the following indicators available for the year 1998-99

1. Total foodgrain production ('000 tonnes)
2. Total foodgrain productivity (kg/ha)
3. Total cereal production ('000 tonnes)
4. Total pulse production ('000 tonnes)
5. Total oilseed production ('000 tonnes)
6. Area and production of fruits (area - ha, Prod. - t)
7. Area and production of vegetables (area - ha, prod. - t)
8. Area and production of flowers (area - ha, production - t)
9. Gross State Domestic Product (GSDP) in (Crores Rs.)
10. Agriculture Gross State Domestic Product (ASDP) in (Crores Rs.)
11. Total Consumption of Fertilizer (t)
12. Consumption of plant nutrients per unit of gross cropped area (NP&K kg/ha)
13. Areas under green manure (Lakh ha)
14. Consumption of total pesticides (t tech. grade)
15. Production of rural and urban compost (Lakh t)
16. Net area irrigated ('000 ha)
17. Estimated area of wastelands (million ha)
18. Total sub-divisional normal rainfall (mm/year))
19. Literacy rates by sex-2001 (percentage)
20. Poverty line in rural and urban areas (Rs/capita/month)
21. Population below poverty line (percentage)
22. Acreage per draught animal pair in India (ha/animal-pair)
23. Distribution and growth of bullocks (million)
24. Livestock (number) and dung production (t)
25. Energization of pump sets (number)
26. Distribution of family type biogas plants (number of installations)
27. Installation of solar photovoltaic pumping systems (number of installations)
28. Installation of solar photovoltaic systems (number of installations)
29. Distribution of solar thermal systems (number of installations)
30. Potential availability of agriculture based biomass (million t)

The above indicators that measure the different characteristics of agricultural development were used to compute the composite indices of agricultural development for each state.

Result and Discussion

The development indices based on 30 indicators regarding agricultural development have been computed for the 25 states of India. Table 1- embodies the values of composite development index for each state along with the rank allotted to the state on the basis of these indices.

The index of development is non-negative and it ranges from zero to one. The measurement near to zero indicates that the state is developed whereas the index near one indicates that the state is less developed.

It can be seen from the table referred to above that the lowest index of 0.3416611 was for the state of Punjab. Thus, Punjab state turns out as the agriculturally the most developed state in India. The possible reasons for it are well known. Several other studies (Alagh and Bhalla 1979b; and Vijayaragavan (1987b) have also concluded that Punjab is agriculturally most developed state in the country. This state was closely followed in

Table 1: Composite Development Index for the States of India

S.No	Name of the State	Pattern of Development(Ci)	Development index(Di)	Rank
1	Andhra Pradesh	17.62509175	0.42436942	7
2	Arunachal Pradesh	21.65056084	0.52129294	23
3	Assam	19.22884979	0.46298402	13
4	Bihar	18.27945589	0.44012492	9
5	Goa	18.5685558	0.44708575	10
6	Gujarat	18.77604308	0.45208153	11
7	Haryana	15.18331715	0.36557742	2
8	Himachal Pradesh	19.85481335	0.4780557	16
9	Jammu & Kashmir	21.69189935	0.52228828	24
10	Karnataka	16.57917594	0.39918631	5
11	Kerala	38.84696387	0.93534058	25
12	Madhya Pradesh	19.49777864	0.46945918	14
13	Maharashtra	17.9620132	0.43248167	8
14	Manipur	20.64952431	0.49719041	19
15	Meghalaya	20.74648722	0.49952505	20
16	Mizoram	21.40100925	0.51528435	22
17	Nagaland	21.02180734	0.50615409	21
18	Orissa	18.96068893	0.45652736	12
19	Punjab	14.19001435	0.3416611	1
20	Rajasthan	19.70125524	0.4743584	15
21	Sikkim	20.52976299	0.49430685	18
22	Tamil Nadu	15.89616426	0.38274104	3
23	Tripura	20.18485541	0.48600232	17
24	Uttar Pradesh	16.79224414	0.40431647	6
25	West Bengal	16.01970227	0.38571554	4

order by Haryana with the index of 0.36557742. The states next in order were Tamil Nadu, West Bengal and Karnataka with the indices of 0.38274104, 0.38571554 and 0.3991831, respectively. The regions of higher rate of agricultural progressiveness of these states could be ascribed to better infrastructural facilities as well as better support systems provided by the State Government including supply of inputs including quality seeds, fertilizers and pesticides, better marketing facilities, easy availability of credit, and government policies.

Punjab state turns out as the agriculturally the most developed state in India.

Interestingly, the highest composite index of 0.93534058, closer to one, was for the state of Kerala indicating least agricultural development in the state. This calculation, despite Kerala being a highly-developed state, is due to the reason that the state's major production and income are from plantation crops which have not been taken into account in these calculations. Likewise, Himachal Pradesh also had a fairly low index for the reasons mentioned above. The development index (0.4780557) next to Kerala, was for the state of Jammu & Kashmir (0.52228828) closely followed in order by Arunanchal Pradesh (0.52129294), Mizoram (0.51528435) and Nagaland (0.50615409). These states can be said to be in the relatively lower level of agricultural progressiveness. It is interesting to note that other states of the north-eastern hill region had a slightly higher index showing relatively better agricultural progress. However, the variations in the index were marginal only. These least progressive states could be due to very slow improvement in infrastructural support system as well as other factors which help in agricultural development in a region/locality.

The highest composite index was for the state of Kerala indicating least agricultural development in the state.

It is an interesting observation that the computed indices for the remaining 15 states were between the range of 0.40 to 0.50. These states, based on development index values could be arranged as Uttar Pradesh (0.40431647), Andhra Pradesh (0.42436942), Maharashtra (0.43248167), Bihar (0.44012492), Goa (0.44708575), Gujarat (0.45208153), Orissa (0.45652736), Assam (0.46298402) Madhya Pradesh (0.46945918), Rajasthan (0.4743584), Himachal Pradesh (0.4780557), Tripura (0.48600232), Sikkim (0.49430685), Manipur (0.49719041) and Meghalya (0.49952505). All these 15 states can, thus, be categorized at the middle level of agricultural development.

Though the index values for all states are almost on the expected lines, the index for Bihar state is unusually high. This is a matter of concern. The agro-climatic conditions of the state, no doubt, are highly conducive for high agricultural development, but natural calamities coupled with extremely poor infrastructural facilities prevailing in the state force a person to think whether the production data reported is correct. If the data is correct, then there is no doubt that the state has tremendous potential for agricultural development, in case the State Government provides adequate attention, in practice, for agricultural development.

All the states of the country can be divided into three broad categories based on the percentile values

of the development indices. The states, which are in the highly developed states category, have D_i values equal to 25th percentile or less than 25 percentile. The D_i value for 25th percentile is 0.4243 for the state of Andhra Pradesh. The states, which are in the moderately developed states category, have the percentile value between 25th to 75th percentile. The D value for 75 percentile is 0.4971 for the Manipur State and the least developed States have D_i values greater than the 75th percentile. Among different states of the country, Punjab is the most developed state followed by Haryana and Tamil Nadu. The states of Bihar, Goa, Madhya Pradesh are under Moderately Developed States while the North Eastern states like Assam, Nagaland etc. of India come under the category of least Developed States. The three broad categories can be summarized as under:

i. *Highly-Developed States*: Punjab, Haryana, Tamil Nadu, West Bengal, Karnataka, Uttar Pardesh and Andhra Pradesh.

ii. *Moderately-Developed States*: Himachal Pardesh, Madhya Pradesh, Bihar, Goa, Rajasthan, Gujarat, Maharastra, and Orissa,

iii. *Least-Developed States*: North Eastern States including Assam, Jammu & Kashmir and Kerala.

From the above it is evident that the states could effectively be categorized based on 'Progressiveness Index' proposed in this study. As stated earlier, only foodgrain, and fruit and vegetables production and the factors influencing these are considered in the agricultural progressiveness index compilation, whereas several states also have plantation crops, animal-based production (milk, meat, egg etc.) and fisheries as important components of agricultural income. Therefore, these components also need to be included in the 'Agricultural Progressiveness' Study. This is suggested as an area for further investigation.

References

Alagh, K.A & Bhalla, G.S. (1979), "Performance on Indian Agriculture", Sterling Publishers, New Delhi.

Aiyar, S. (2003), "India's Worst", India Today, August 25; pp 42-44.

Bennet, M.K. (1951), "International disparities in consumption levels", American Economic Reviews, XL1;632-649.

Dasgupta, B. (1971), "Socio-economic classification of districts – A Statistical Approach", Economic and Political Weekly, 6(33); August 14.

Mukharjee, M. (1980), "Physical Quality of Life Index"; Bombay; Centre for Monitoring Indian Economy.

Pal, M.N. (1972), "Regional Studies for consistent plan formation; the need for write kind of orientation", Indian Journal of Regional Science, Vol. V, No.1.

Rao, S.K. (1973), "A note on measuring economic distances between regions in India", Economic and Political Weekly, 8(7): April 28.

Vijayragvan, K. (1987), "Agricultural Administration in India – A Comprehensive Study", Concept Publishing, New Delhi.

□

Experience is one thing you can't get for nothing.

– Oscar Wilde

Feature

Performance of Livestock Sector in India

A. Vidhyavathi, M. Shantha Sheela & P. Balaji

This study has been undertaken to provide empirical evidence on the performance of the livestock sector, particularly relating to sources of growth and productivity changes. The transitional probability matrix indicates that the retention share of the livestock sector would be higher than the agricultural sector in the future. The transitional probability matrix for different components in total output value of livestock showed that milk group would have the highest retention of share in total output. The growth rate of total factor productivity is 1.04 per cent per annum, which implies that gradually technology is becoming a driving force in the growth of the livestock sector.

A. Vidhyavati is Research Associate, M. Shantha Sheela is Senior Research Fellow and P. Balaji is Senior Research Fellow at Tamil Nadu Agricultural University.

The Indian livestock sector has recorded impressive growth in recent years. It contributes an estimated 8 to 10 per cent to the country's Gross Domestic Product (GDP) and 26 per cent to the agricultural output at current prices (Economic Survey, 1997-98). It is the principal source of draft power in rural areas and provides milk, meat, eggs, wool, hides and skins, manure and fuel. Since the early 1970s, this sector has witnessed several significant changes, most of which are direct or indirect consequences of Operation Flood, the green revolution or upsurge in demand. These changes have important implications for future growth of the livestock sector, diversification of rural economy and growth and structure of the country's agricultural GDP. Inspite of its importance, this sector has not received as much economic research attention as the crop sector. This study has attempted to provide empirical evidence on the performance of livestock sector particularly relating to sources of growth and productivity changes.

The objectives of the present study are:

(i) To study the growth pattern and share of livestock sector in the country's Gross Domestic Product.

(ii) To study the growth pattern and share of various livestock output in total value of livestock output.

(iii) To analyse productive performance of the livestock sector at aggregate level.

Sources of Data and methodology

This study is mainly based on secondary data from various sources, including the Livestock Censuses, National Accounts Statistics, Technical Committee Report for Direction and Improvement of Animal Husbandry and Dairying Statistics, Agricultural Prices in India, Agricultural Wages in India, NSS report on Employment, Indian Poultry Industry Year book, Annual Reports of Poultry, FAO year book various issues.

Tabular, percentage analysis and annual compound

growth rates were computed for shares of different sectors to GDP and livestock output. The time period was 1970-71 to 1997-98.

$\ln Y_t = B_1 + B_2 t$

Y_t = Time series data for which CGR to be estimated

T = Time period from 1970-71 to 2000-01

B_1 = Intercept

B_2 = Slope coefficient

The Compound Growth Rate (CGR) was obtained using the formula

(CGR) = (AntilogB_2 – 1)x 100.

Markov Model

The structural change in the share of different sectors in the country's GDP and various components in the total output value from the livestock sector were analysed through a first order Markov model, in order to have better insight into the dynamics of the changes.

The model is a stochastic process, which described a finite number of possible outcomes, i.e., of a discrete random variable X_t with the assumption that (i) the probability of an outcome on the t^{th} year depends only on the outcome of the preceding year (t-1) and (ii) this probability is constant for all time periods. The important aspect in Markov Chain Analysis was the estimation of the transitional probability matrix 'P'. The element Pij of this matrix indicates the probability that share will switch from sector I in period t-1 to sector j in the next year t. The diagonal element "Pii" measures the probability that the GDP share of a sector would be retained in the next year. An examination of this matrix would indicate direction of GDP to a particular sector.

In the present study, in analyzing the direction of shares of GDP five sectors were considered viz., agricultural sector, forestry and fishery sector, livestock sector, industrial sector and service sector. In case of total value of output from the livestock sector six components were considered viz., milk group, meat group, eggs, wool and hair, dung and silk worm cocoons and honey. To estimate the transitional probability matrix, the annual GDP data and total value of output from livestock sector (1992-93 to 1997-98) were used. In this study, for use of Markov Analysis, the GDP share to a particular sector was considered to be a random variable. The following first order Markov Model was used.

$$E_{jt} = \sum_{i=1}^{r} E_{it-1} P_{ij} + e_{jt}$$

Where

E_{jt} = GDP share during the year 't' to j^{th} sector

E_{it-1} = GDP share to i^{th} sector during the year t-1

P_{ij} = Probability that share will shift from ith sector tin period t-1 to jth sector in period t

e_{jt} = The error term which is statically independent of E_{it-1} and

r = The number of sectors.

The transitional probabilities P_{ij} which can be arranged in a (rxr) matrix, have the following properties.

$O \leq P_{ij} \leq 1$ for all i and j

$$\sum_{i=1}^{r} P_{ij}\ 1 \text{ for all } j$$

Lee etal used the Linear programming framework by a method referred to as Minisation of Mean Absolute Deviation (MAD) to estimate the transitional probability matrix. This analysis leads to the formulation of the following LP problem, which can be selected to estimate the transition probabilities.

(for each i) P_{ij} , j = 1,2 ..... r and i = 1,2.....r

Model

For each i, to determine P_{ij}, j = 1,2.....r

which minimizes

$$Z = \sum_{j=1}^{r} o\, P_{ij} + \sum_{k=1} \theta_k + \sum_{k=1} \rho_k$$

Subject to

$$Z = \sum_{j=1}^{r} x_{ij} P_{ij} + \theta_i - \rho_i = Y_i$$

$$\sum_{j=1}^{r} P_{ij} = 1 P_{ij} = 1$$

$P_{ij} \geq O$, j = 1,2,.....r

$\theta_k, \rho_k > O$, k = 1,2.....T

Where

x_{ij} = Share of GDP from in sector to j^{th} sector during year t.

Y_i = Share of GDP to sector i during the year t

θ_k, ρ_k = Variables denoting absolute errors.

This is repeated for each sector to estimate the entire transition probability matrix P. The expected GDP share of each sector in period t can be obtained by multiplying the GDP share to these sectors in previous period (t-1) with transitional probability matrix.

Total Factor Productivity

The total factor productivity implies an index of output per unit of total factor inputs, measures real productivity change as defined by a shift in the production function properly, holding all inputs constant. It measures the amount of increase in total output which is not accounted for by increase in total inputs. Tornquist – Theil Divisia Chained index number approach was used for measuring Total Factor Productivity.

The formula for Thornquist – Theil Index of total output index is

$$\ln QI_t = \sum_i 1/2 * (Si_t + Si_{,t-1}) * \ln (Y_{it}/Yi_{,t-1})$$

$$\frac{TQI_t}{TQI_{t-1}} = (Y_{it}/Yi_{,t-1})^{(Sit + Si,t-1)1/2}$$

Where

$\ln QI_t$ is the log of the total output index at time t.

Si_t and $Si_{,t-1}$ = Output i's share in total production value at time t and t-1respectively.

Y_{it} and $Yi_{,t-1}$ = Quantities of output i at time t and t-1 respectively

And i = 1,2.....n

The output index covered milk and milk products, meat and meat products, animal draft power, dung (fuel + manure), eggs and poultry meat, hides and skins, wool and hair and other by products (guts, blood, bones, harns, silkworm cocoon and honey).

$$\ln TII_t = \sum_j 1/2 * (W_{jt} + W_{j,t-1}) * \ln (X_{jt}/X_{j,t-1})$$

$$\frac{TII_t}{TII_{t-1}} = \sum_j (X_{jt}/X_{j,t-1})^{(Wjt + Wj,t-1)1/2}$$

Where

$\ln TII_t$ is the log of the total input index at time t.

W_{jt} and $W_{j,t-1}$ = the cost shares of input in total cost at time t and t-1 respectively.

S_{jt} and $S_{j,t-1}$ = Quantities of input i at time t and t-1 respectively

To estimate the input index, feed, labour and livestock population was considered. Livestock feed comprises of roughage and concentrates including salt, medicines and other miscellaneous feed.Total factor productivity is defined as total output minus total input.

$$\ln TFPt = \ln QIt - \ln TIIt$$

$$TFP_t = \frac{TQI_t}{TII_t}$$

Where

$\ln TFP_t$ is the log of total factor productivity index.

Results

Performance of livestock sector in Gross Domestic Product.

During the last decades the contribution of the agriculture sector to the GDP of the country has declined. However the contribution of the livestock sector to the GDP has improved and it has registered positive and significant compound annual growth rate of 13.02 per cent (Table 1). The CGR was less for agriculture compared to other sectors including GDP.

Table 1: Gross Domestic Product by economic activity, compound growth rate and its percentage composition (Three yearly average at current Prices)

S.No	Sectors	CGR	Percentage composition
1	Agriculture sector	10.59	18.57
2	Forestry and Fishery	12.98	2.26
3	Livestock	13.02	7.54
4	Industrial sector	14.52	26.46
5	Service Sector	15.62	45.17
	GDP	14.12	100

From Table 2 it could be evidenced that the agricultural sector had a retention share of GDP share 0.1113. Similarly the forestry and fishery sector and livestock had a small retention of GDP shares, ie 0.1618 and 0.1542 respectively.

These three sectors lose nearly 0.33 GDP share to the industrial sector and nearly 0.20 GDP share to the service sector. But the industrial sector and service sector were found to be holding a GDP share of 0.3235 and 0.3977 respectively. The service sector also loses a con-

siderable share to the industrial sector, ie 0.3041. These results compare to the CGR analysis where industrial sector and service sector had a very high growth rate (nearly 15 per cent per annum).

Table 2: Transition Probability Matrix of GDP contribution of various sectors

	Agrl.	Forestry & Fishery	Livestock	Industry	Services
Agrl.sector	0.1113	0.1299	0.1474	0.3331	0.2783
Forestry & Fishery	0.1617	0.1618	0.1639	0.3326	0.1800
Livestock	0.1651	0.1460	0.1542	0.3242	0.2105
Industry	0.1616	0.133	0.1451	0.3235	0.2368
Services	0.1239	0.0692	0.1051	0.3041	0.3977

By and large, the value of output from livestock sector and its components registered positive and significant rates. The highest growth rate was for (Table 3). Meat and meat products is also a major contributor to the output of livestock. Livestock sector as a whole registered an annual growth rate of 3.64 per cent while the agricultural sector grew at 2.95 per cent per year.

Table 3: Total value of output from livestock sector, Compound Growth Rate (CGR) and its percentage composition (Three years average at current prices)

S.No.	Items	CGR (1970-71 to 2000-01)	Percentage composition
1	Milk group	4.27	67.25
2	Meat group	4.32	18.94
3	Eggs	5.77	3.34
4	Wood & Hair	0.48	0.27
5	Dung	1.29	8.81
6	Silk worm cocoons and honey	1.42	1.39
7	Total value of output from livestock sector	3.64	100
8	Total value of output from agriculture	2.95	

The transitional probability matrix for different components in total output value of livestock is given in Table 4. Milk group had a highest retention of share in total output value, ie 0.7091 and it loses a share of 0.2057 to the meat group. Other components like meat group, eggs, wool and hair, dung were found to hold a small share in output value ie 0.1827, 0.1580, 0.1857 and 0.1426 respectively. Silkworm cocoon and honey component had a considerable retention share of 0.3892.

Table 4: Transition probability matrix of GDP contribution of livestock products

Items	Milk group	Meat group	Eggs	Wool & Hair	Dung	Silk worm co-coons and honey
Milk group	0.7091	0.2057	0.0227	0	0.0625	0
Meat group	0.3443	0.1827	0.1298	0.1158	0.1408	0.0866
Eggs	0.1986	0.1498	0.1480	0.1613	0.1489	0.1935
Wool & Hair	0.1611	0.1187	0.1350	0.1857	0.1344	0.2652
Dung	0.2566	0.1579	0.1376	0.1451	0.1426	0.1603
Silk worm cocoons and honey	0.1407	0.0711	0.1019	0.1939	0.1033	0.3892

Table 5: CGR in production and yield of livestock product (1970-2001)

Livestock products	Production (%)	Yield (%)
Milk		
Cow milk	5.15	3.16
Buffalo milk	4.41	1.94
Meat		
Beef and Veal	7.08	0.15
Buffalo meat	4.11	–0.01
Mutton & Lamb	2.22	0.07
Goat meat	2.36	0.52
Pig meat	6.26	0.12
Poultry meat	5.65	-
Total meat	4.22	-
Eggs	5.58	-

Table 6 gives the output index, input index and total factor productivity of livestock sector for the period from 1971 to 2001. The CGR of TFP is 1.04 per cent per annum. Technology has contributed substantially to livestock growth. TFP index, a measure of contribution of technology has been growing at an annual rate of 1.04% since 1970, while in the pre-1970 growth the TFP index was marginally negative, iw –0.04 per cent per annum (Birthal et al 1999). This implies that gradually technology is becoming a driving force in the growth of livestock sector.

The growth rates were calculated for livestock inputs namely feed, labour and population and is presented in Table 7 as production and productivity trends will provide a fair assessment of the impact of technology. As expected livestock feed registered higher annual growth rate compared to labour and

population stock. Like that the feed has occupied major factor shares followed by labour.

Table 6: Tornquist – Theil Total Factor Productivity Index of livestock sector

Year	Input Index	Output Index	Total Factor Productivity Index
1971	1.05	1.02	0.97
1972	0.98	0.99	1.01
1973	0.91	0.95	1.04
1974	1.02	1.00	0.98
1975	1.07	1.05	0.98
1976	0.94	1.01	1.07
1977	1.14	1.17	1.03
1978	0.85	1.18	1.39
1979	1.08	1.09	1.01
1980	0.89	1.08	1.21
1981	1.04	1.00	0.96
1982	1.08	1.15	1.07
1983	0.84	1.02	1.22
1984	0.90	1.02	1.13
1985	0.79	0.85	1.07
1986	0.73	1.00	1.37
1987	0.91	1.05	1.15
1988	1.10	1.18	1.07
1989	1.12	1.24	1.11
1990	1.08	1.20	1.02
1991	1.14	1.14	1.00
1992	1.01	1.08	1.07
1993	1.05	1.17	1.11
1994	0.72	1.07	1.48
1995	1.07	1.36	1.27
1996	0.78	1.18	1.52
1997	0.87	1.15	1.32
1998	0.86	1.27	1.48
1999	0.72	1.18	1.64
2000	0.99	1.15	1.16
2001	1.01	1.32	1.31

But growth and technical change has affected the composition of livestock feed. In 1970-71, dry fodder accounted for around 58 per cent of the total livestock feed. This came down to 35% in 1997-98 (Table 8). The share of green fodder increased from 40 per cent to 57 per cent during the above period. The percentage share of concentrates was around 2 per cent in 1970-71 and remained almost constant upto 1981-82, but since it has increased significantly and has reached 7.63 per cent in 1997-98.

Table 7: Compound Growth Rate of inputs

Livestock inputs	CGR (%)	Factor shares (%)
Feed	1.57	61.72
Labour	0.44	23.92
Population stock	0.19	14.36

Table 8: Composition of livestock feed in India

(%)

Livestock feed	1950-51	1970-71	1981-82	1997-98
Dry fodder	59.74	57.76	46.75	35.38
Green fodder	37.74	40.19	50.62	56.98
Concentrates	2.52	2.05	2.63	7.63

With better market opportunities and commercialization, producers now have the incentive to switch from subsistence oriented, supplementary livestock rearing to market-oriented pattern.

The adoption of milch crossbred cattle has brought about an immediate upward shift in the threshold level of milk yield, enabling the farmers to get more milk at the existing level of input use (Table 9). Average milk yield of a crossbred in milk cow in 1993-94 was 5.8 kg/day, which was about 3.5 times more than that of a milk indigenous cow. In milk crossbred cows comprised 14.2% of the total in milk cow and contributed 36.3% to total cow milk production. Buffalo accounted for 45% of total milk bovines and contributed 57% to total milk production.

Table 9: Contribution of Crossbred Cows at Milk Production

Particulars	Indigenous cow	Crossbred cow	Buffalo
Share in milch stock (%)	47.4	7.9	44.7
Share in milk production (%)	27.7	15.8	56.5
Milk yield (Kg/animal/day)	1.69	5.81	3.65

Source: Department of Animal Husbandry and Dairying Ministry of Agriculture, GOI,(1999).

Between 1970 and 1998 cow and buffalo milk production grew at a rate of 5.2 and 4.4 per cent a year respectively, while their productivity increased at a rate of 3.2 and 1.9 per cent respectively and their contribution was about 61 per cent to their respective output growth.

Conclusions and policy implications

- The production growth is gradually becoming productivity centered.
- There is considerable scope for increasing production through substitution of indigenous animals with the improved/crossbred animals.
- Adoption of cross breeding technology, however, has been slow. Only 7.5 per cent of the cattle population is of crossbreeds.
- Buffalo is another important milch species (18% in livestock population). But it has not received much attention in breed improvement research.
- Development efforts need to be focused on upgradation of low yielding breeds through artificial insemination.
- Higher initial investment and maintenance costs could be another limitation to widespread adoption of crossbreeds.
- There exists a large gap between both requirement and availability of feed and fodder at national level.
- The feed and fodder deficiency is because of heavy population pressure, quantitative and qualitative deterioration in common grazing lands resulting in low biomass production for animal feed and lack of adoption of fodder production technologies.

There is lack of concerted efforts to transfer these technologies and to demonstrate their cost benefit ratios for their wider adoption. Technological change embodied in better breeds, improved health, nutrition and processing must be accorded high priority along with credit, marketing and organization of producers to further this trend.

□

What is work and what is not work are questions that perplex the wisest of men.

– Bhagavad Gita

Feature

Scope & Constraints of Growth in Productivity of Coconut in Kerala

M. Lathika, V. Mathew Kurian & C.E. Ajith Kumar

The two crops that have exhibited a steady rise in area in Kerala, namely coconut and rubber, have scaled the peaks of their acreage at the expense of other crops, which are traditionally the chief calorie-donors of the state. Area growth is hence no substitute for productivity growth of coconut in Kerala. Not only the planners but also the farmers themselves have already discerned a gap between the actual and the potential. An analysis was done in this paper to identify the constraints to productivity growth of coconut, their intensity and spread along the spatial and temporal axes.

M. Lathika is Lecturer in the Department of Economics, NSS College for Women, Neeramankara, Thiruvananthpuram, Kerala; V. Mathew Kurian is Visiting Professor, M.G. University, Kerala; and C.E. Ajith Kumar is a programmer, College of Agriculture, Kerala Agricultural University, Thiruvananthapuram.

Agriculture still holds the key to the growth of the Indian economy, even with the remarkable strides in the non-agricultural sectors of the nation. It contributes nearly 25 per cent of GDP and 70 per cent of the population in India is dependant on agriculture for their livelihood. In the ten year period from 1991 to 2000, foodgrain area had ranged from 123 million hectares to 130 million hectares (GoI, 2001). The country has reached a plateau in so far as the area devoted to foodgrain production is concerned. Any increase in production in the country is, therefore, to come through increase in productivity.

Coconut occupies an important position in the agricultural arena of the nation. More than 10 million people depend on coconut cultivation, processing and related activities. Production of coconut in the country reduced from 12,720 million nuts in 1997-98 to 12,600 million nuts in 2000-01. Reduction is mainly attributed to the attack of the eriophyid mite in coconut plantation in the southern states (GoI, 2003).

Kerala assumes an outstanding domain in the coconut map of the country. Of the total coconut land of India, Kerala has occupied 49.7 per cent and is the largest supplier (44.8 per cent) of coconut towards the nation (Coconut Development Board, 2004). But productivity of coconut in Kerala has been found to be fluctuating very much over the years and it has become the lowest among the major coconut cultivating states of India in the year 1998-99 (GoK, 2001). Moreover, per palm yield has also come down to its lowest ebb in Kerala with 33 nuts per palm per year, as against that of the neighbouring states of Karnataka and Tamil Nadu with 44 and 54 nuts per palm per year respectively (Ohler, 1999). The hegemony of the state in the coconut affairs of the country appears to be gradually waning.

The problems faced by the coconut crop in Kerala could better be explained within a larger context of the performance of other crops in relation to coconut.

Before making an inquiry into the productivity deterring factors of coconut, a preliminary knowledge of the agricultural scenario of Kerala, with the relative importance of the various crops cultivated, and the percentage share of area devoted to each crop to the net sown area, is essential.

The output growth of a crop could be attained either by bringing more land under cultivation of the crop or by an improvement in productivity or by a combination of both. When the scope for increasing production through area expansion is limited, productivity becomes the key factor in the determination of output. Attempts to map the variability in productivity usually involves the study of the association of a set of few variables covering only some aspects of the crop growth, the size of which is not only constrained by the survey allocations and response reliability, but also by the restrictions imposed upon the statistical tools employed. One way out is to collect the perception of the respondents on all aspects of crop growth and resort to non-parametric methods of analysis. Constraints analysis assumes importance in this context. Existence of a constraint is assumed when a gap between the actual and perceived yield levels is identified. Kerala has the most conducive conditions for coconut cultivation on account of her rich natural endowments, the tradition and affinity of the people of Kerala towards the cultivation of this crop, high share of labour dependence on the cultivation of the crop and allied activities and the preference for raw coconuts. The production potential of coconut in Kerala, which is estimated to be 12388.6 million nuts (Appendix 4 of GoK, 1997), is much higher than the current production. Moreover, coconut farmers of Kerala have a widely varied perception of the production potential of their coconut farms and they are sufficiently aware of their limitations to attain the perceived yield levels.

Keeping in mind these factors, the present study is undertaken with the following objectives:-

- Identify the scope and current status of coconut as against other major crops in the net sown area of Kerala.
- Analyse the different constraints faced by the coconut cultivators of Kerala from the spatial and temporal dimensions and identify, thereby, the most serious constraints the farmers confront.

Data and Methodology

The study is segmented mainly into two to meet its twin objectives. Data obtained from various governmental sources like the Department of Economics and Statistics, Planning Board have been considered for the first part of the study. The constraints analysis is based on the primary data collected from three districts of Kerala belonging to three different agro-climatic regions through a sample survey. A stratified multi-stage random sampling design has been used for the sample survey. For the purpose of sampling, a coconut cultivator is defined as a farmer who has either ten coconut palms or twenty cents of land under coconut cultivation. 100 randomly selected coconut cultivators, each from Thiruvananthapuram, Kottayam and Kasaragod districts of Kerala belonging to southern (region 1), central (region 2) and northern agro-climatic (region 3) regions of Kerala, respectively, form the sample. Factors that directly and indirectly influence the yield of coconut were collected by surveying the coconut literature and a list of 17 constraints that were reported to be deterring the yield levels of a coconut farm are short-listed on the basis of the judges' rating (Edwards, 1969; Singh, 1997) and included in the survey instrument. Data on three dimensions of each of these constraints were collected, which are, one, the proportion of area under coconut which is plagued by the constraint, two, number of years since affected and three, severity code (ranging from 1 to 5) denoting the intensity with which the constraint tends to impede the yield levels.

The analysis in the second part of the study has been based on a theoretical framework as described below.

Let n be the number of constraints, m be the number of farmers and $\{a_{ij}: 1 \le i \le n, 1 \le j \le m\}$, $\{ b_{ij} : 1 \le i \le n, 1 \le j \le m\}$ and $\{ c_{ij}: 1 \le i \le n, 1 \le j \le m\}$ be observation matrix corresponding to the three dimensions of the constraints. The index C_i for the intensity of the i^{th} constraint is computed (Prakash, 1991) using the equation:

$$C_i = \frac{100}{m.c_{max}} \sum_{j=1}^{m} c_{ij}$$; where c_{max} is the maximum score for intensity.

Coconut is a perennial crop with a long life span running to many decades, although it varied from cultivar to cultivar. Not all the constraints affect all the palms in equal measure or severity. A constraint index we develop must, therefore, differentiate from the sparingly affected temporary ones and the ones with permanent or of very long duration and widely spread. In other words, the index must have a spatial and temporal dimension embedded into it. From the equation on the constraint intensity index given above, it could be articulated that C_i is devoid of the spatial and temporal spread of the constraint. A composite index that encompasses

both the space (here, proportion of the land affected) and time (here, number of years) dimensions of the constraints is given by the formula (Lathika, 2002),

$$D_i = \frac{100}{m.a_{max}.c_{max}} \sum_{j=1}^{m} c_{ij} \,.\, b_{ij} \,.\, c_{ij}$$; where a_{max} and c_{max} are the maximum values that could be attained respectively. It may be noted that, as this composite index encompasses all the three dimensions of the scale on constraints, this index stands to manifest both the intensity and persistence of the constraint as being perceived by the farmer in his farm(s).

Results and discussion

Available data shows that in the early 1960s, more and more land was brought under cultivation in Kerala. The net sown area in 1960-61 was 1,924,000 hectare and it maintained an upward thrust till the mid-70s (Statistics for Planning, Government of Kerala, various issues). After that, the net sown area began to show only mild increases, which is shown in table 1. Index (1960 base year) shows that net sown area has increased to 112.58 by the 10-year period from 1960-1969. After that the growth index of net sown area has reached only 114.09 in 1979 and 116.01 in 1989. After 1989, there was only meagre increase in net sown area having only an average annual growth rate of 0.03. Net sown area has shown a growth rate of 0.29 for the period from 1960-99. While the period 1960-74, which was designated by Kannan and Pushpangadhan (1990), was, comparatively, the expansion phase of the net sown area, the second phase is a stage characterized by relative gains and losses of area under different crops.

While the period 1960-74, which was designated by Kannan and Pushpangadhan (1990) as 'pre-stagnation period of agriculture in Kerala' was, comparatively, the expansion phase of the net sown area, the post-stagnation period is a stage characterized by relative gains and losses of area under different crops. Area under major crops in Kerala (Table 2) shows that nearly 73 per cent of net sown area was occupied by paddy and coconut in 1969 (40.35 per cent by paddy and 32.68 per cent by coconut). Percentage contribution of paddy to net sown area declined sharply to 15.62 per cent in 1999 followed by tapioca, whose share became nearly one-third in 1999 when compared to 1969 figures. Rubber and coconut are the two crops whose share in net sown area has increased sharply. In the year 1999, coconut has become the crop occupying the largest share of net sown area (41.31 per cent). Average annual growth rate in area achieved by coconut is 1.12 in 1999 and 1.93 by rubber and the other two crops, paddy and tapioca showed a declining trend of -4.00 and -3.18 respectively.

Table 1: Net sown area in Kerala from 1960-99

Period	Average annual growth rate	Index with 1960 as the base year
1969	1.40	112.58
1979	0.13	114.09
1989	0.17	116.01
1999	0.03	116.37

Source: Computed from data provided in Government of Kerala, Statistics for Planning (various issues), The Economic Review (various issues) of State Planning Board.

Area changes under coconut plantation should be discussed in a larger context of area changes of other crops in Kerala. Hence correlation has been worked out to understand the degree of association of the area under different crops.

Table 3 shows that out of the four major crops considered for correlation analysis, only rubber and

Table 2: Area changes under major crops in Kerala from 1960 to 1999

Crops	Percentage of NSA in the years				Average annual growth rate for the decade ending			
	1969	1979	1989	1999	1969	1979	1989	1999
(NSA)	(55.75)	(56.49)	(57.44)	(57.62)	1.40	0.13	0.17	0.03
Paddy	40.35	36.14	26.14	15.62	1.36	-0.92	-2.65	-4.00
Tapioca	13.65	11.11	7.18	4.88	2.45	-1.75	-3.43	-3.18
Rubber	8.09	9.87	17.76	21.12	4.73	2.36	8.31	1.93
Coconut	32.68	30.27	37.28	41.31	4.59	-0.61	2.52	1.12

Source: Computed from data provided in Government of Kerala, Statistics for Planning (various issues), Department of Economics and Statistics, Thiruvananthapuram; Government of Kerala, The Economic Review (various issues) State Planning Board, Thiruvananthapuram.

Note: Values in brackets are corresponding percentages of total geographical area.

coconut could contribute positively to the net sown area. Area under paddy and tapioca are significantly but negatively related to the net sown area. As the net sown area has been on an increase over the years, the negative relation of net sown area with paddy area and also with tapioca area indicates that some other crops had drawn substantially from paddy and tapioca lands. The negative relation between rubber and paddy and also between rubber and tapioca shows that increase in area under rubber is, by and large, at the expense of paddy and tapioca lands. Similarly, coconut acreage has increased by diverting paddy and tapioca lands. Large-scale wet land conversion had taken place, especially after the mid-70s mainly because the price of paddy had plummeted and the price of coconut sky-rocketed, coupled with heavy labour migration and internal labour unrest. Coconut, with its lesser labour-intensive nature, got a comparative advantage against paddy, reflecting on the mutually reverse trends of their areas. Moreover, the high water table in these reclaimed lands also was favourable for the flourishing growth of coconut crop. No area shift is observed between coconut and rubber. Crop shifting by the cultivators is, though, influenced by a variety of factors (soil and climatic suitability, level of management required by a crop, convenience of the crop etc.) and to a larger extent, it is determined by the relative profitability of different crops. Thus, when net sown area remains stagnant or increases only at a slow pace, area increase of one crop becomes possible only at the expense of other crops. As has been stated earlier, this may lead to relative gains and losses in area under various crops. Since there is only very little room for the expansion of agricultural land in the coming years in Kerala, further development in the field of coconut production depend primarily on the productivity performance of the crop.

Table 3: Correlation matrix of area under various crops

	NSA	Paddy	Tapioca	Rubber	Coconut
NSA	1.000				
Paddy	- 0.5010**	1.000			
Tapioca	- 0.3441*	0.9423**	1.000		
Rubber	0.7555**	-0.9236**	-0.8428**	1.000	
Coconut	0.8833**	-0.7623**	-0.6234**	0.9027**	1.000

Source: Government of Kerala, Statistics for Planning (various issues), The Economic Review (various issues), State Planning Board.

Note: * - significant at p = .05; ** - significant at p = .01

Analysis of the data on the constraints to productivity is done separately for all the regions and then it is pooled over the regions. The incidence of these constraints in various regions is presented in table 4. The table brings to light the incidence of these constraints across regions. The prevalence rate of these constraints is not the same over the regions. The 'pest and disease' infestation that remains uncontrolled is the most prevalent constraint faced by the farmers, followed distantly by the 'lack of a stable market for coconut products'. A small fraction of only three per cent farmers reported the non-availability of chemical fertilizer and six per cent farmers reported the non-availability of pesticides. The number of farmers who reported the use of chemical fertilizers is 31.67 per cent only. The number of farmers who perceived that the availability of chemical fertilizer in the market is not a serious constraint, turned out to be this low probably due to the fact that the market could sufficiently meet the fertilizer demand of the farmers which, in turn, is very meagre. However, the survey reiterates that the number of farms reported to be pest-attacked is as high as 73.33 per cent. Yet, the availability of pesticides did not figure to be a serious constraint to many a farmer. This implies either that it was readily available in the market or that the farmers are not in the habit of applying these as prescribed in the package of practices (KAU,1996), even when the situation warrants it so gravely.

The index on the intensity of the constraint is devoid of the spatial or temporal dimensions. However, the average of these constraints across all the farmers in each of the regions and for the state as a whole is computed and presented in table 5. The constraints are then ranked, within each region, according to the average score they obtained, for the sake of comparison between intensity of these constraints. The table of constraint-intensity index also emphasises that availability of inputs like pesticides, chemical fertiliser are hardly a severe constraint in region 2 and 3, though, farmers in region 1 report it to be also a moderate constraint (rank – 6). The farmers in all the regions are equivocal in stating that financial assistance also does not pose a great constraint (rank – 3 in all regions). Finding a stable market does seem to be a great constraint in region 1 and 3. However, it really is a constraint in region 2. Labour availability is undeniably a severe constraint in region 1 and 2. But it is still a moderate constraint in region 3, where labour input and cost incurred on its account and planting density is the least.

Among the three measures of constraints considered, the composite index undoubtedly depicts a realistic picture in that the extent of the constraint is latent in the index. These composite indices are put to Kruskal-Wallis one-way analysis of variance for independent sample (Siegel, 1988). The constraints are then compared within respective regions using the critical values computed. The average composite index and the alphabets for comparison of the indices are given in table 6.

Table 4: Incidence of the constraints over the agro-climatic regions

Constraint No.	Constraint	No. of farmers reporting in region (N = 100)			All region	
		1	2	3	No	%
1	Unsuitable land	6	14	33	53	18
2	Submerged land	5	17	15	37	12
3	Inadequate water resources	21	7	17	45	15
4	Bad cultivar	11	20	20	51	17
5	Poor quality seedling	5	7	10	22	7
6	Unscientific planting	26	10	28	64	21
7	Senile palm	8	11	14	33	11
8	Uncontrolled pest attack	83	68	26	177	59
9	Uncontrolled disease	9	57	35	101	34
	Lack of :					
10	Good quality seedling	9	3	4	16	15
11	Labour	31	28	11	70	23
12	Organic manure	9	6	16	31	10
13	Chemical fertilizer	3	0	0	3	1
14	Pesticide	6	0	0	6	2
15	Stable market	28	6	45	79	16
16	Extension service	13	10	7	30	10
17	Financial assistance	5	3	4	12	4

Table 5: Average intensity of the constraint, by agro-climatic regions[a]

Constraint No.	Constraint	Region (N = 100)			All region
		1	2	3	
1	Unsuitable land	3.0 (4)	8.4 (8)	20.8 (15)	10.7 (12)
2	Submerged land	3.2 (5)	10.8 (13)	8.6 (9)	7.5 (9)
3	Inadequate water resources	11.6 (13)	5.4 (6.5)	11.6 (12)	9.5 (11)
4	Bad cultivar	5.4 (9)	16 (14)	10.4 (10)	10.6 (12)
5	Poor quality seedling	2.0 (1)	6.8 (9)	5.4 (6)	4.7 (5)
6	Unscientific planting	14.8 (14)	7.0 (10)	17.2 (14)	13 (13)
7	Senile palm	5.0 (8)	9.0 (12)	8.0 (8)	7.3 (10)
8	Uncontrolled pest attack	60.6 (17)	53.8 (17)	14.2 (13)	42.9 (17)
9	Uncontrolled disease	4.6 (7)	47.8 (16)	25.8 (16)	26.1 (16)
	Lack of:				
10	Good quality seedling	6.8 (11)	2.2 (4)	2.4 (4)	3.8 (4)
11	Labour	22.8 (16)	25 (15)	7.2 (7)	18.3 (14)
12	Organic manure	5.6 (10)	4.8 (5)	11 (11)	7.1 (7)
13	Chemical fertilizer	2.2 (2)	0.0 (1.5)	0.0 (1.5)	0.7 (1)
14	Pesticides	4.0 (6)	0.0 (1.5)	0.0 (1.5)	1.3 (2)
15	Stable market	20.6 (15)	5.4 (6.5)	41.8 (17)	22.6 (15)
16	Extension service	7.0 (12)	8.0 (10)	4.6 (5)	6.5 (6)
17	Financial assistance	2.6 (3)	1.4 (3)	2.2 (3)	2.1 (3)

[a] Values within the parenthesis are the ranks assigned for the constraint in the region, with lesser average intensity having lesser rank. Those constraints having same hierarchical positions are given the average of their ranks.

Table 6: Average composite index on the intensity and extent of the constraints in different regions

No.	Constraint	Average composite index (N = 100)			
		I	II	III	All region
1	Unsuitable land	0.185 (7)^{ab}	0.249 (7)^{abc}	1.783 (16)^{fg}	0.739 (12)^{abcd}
2	Submerged land	0.080 (4)^{a}	0.651 (14)^{bcd}	0.586 (13)^{bcd}	0.439 (9.5)abcd
3	Inadequate water resource	0.743 (13)^{b}	0.131 (5)^{abc}	1.203 (14)^{bcdef}	0.693 (11)^{bcd}
4	Bad cultivar	0.186 (8)^{ab}	0.460 (13)^{c}	0.543 (12)^{bcdef}	0.396 (7)^{abcd}
5	Poor quality seedling	0.057 (2)^{a}	0.109 (4)^{abc}	0.100 (4)^{abc}	0.089 (3)^{abc}
6	Unscientific planting	0.863 (14)^{c}	0.246 (6)^{abc}	1.803 (17)^{ef}	0.970 (15)^{d}
7	Senile palm	0.534 (12)^{ab}	0.417 (12)^{abc}	0.189 (6.5)^{abcd}	0.380 $^{(6)abcd}$
8	Uncontrolled pest attack	2.880 (17)	2.469 (16)^{e}	0.169 (5)^{cdef}	1.839 (17)^{d}
Lack of:					
9	Uncontrolled disease	0.049 (1)^{ab}	2.520 (17)^{e}	0.249 (8)^{efg}	0.939 (13)abcd
10	Good quality seedling	0.246 (9)^{ab}	0.283 (8)^{abc}	0.080 (3)^{ab}	0.203 (5)^{abcd}
11	Labour	1.029 (15)^{d}	1.480 (15)^{d}	0.346 (9)^{abc}	0.951 (14)^{cd}
12	Organic manure	0.346 (10)^{ab}	0.383 (11)^{abc}	0.517 (11)^{bcde}	0.415 (8)^{abcd}
13	Chemical fertilizer	0.063 (3)^{a}	0.0 (1.5)^{a}	0.0 (1.5)^{a}	0.021 (1)^{a}
14	Pesticide	0.171 (6)^{ab}	0.0 (1.5)^{a}	0.0 (1.5)^{a}	0.057 (2)^{ab}
15	Stable market	1.120 (16)^{d}	0.297 (9)^{abc}	1.549 (15)^{g}	0.989 (16)^{d}
16	Extension service	0.457 (11)^{ab}	0.377 (10)^{abc}	0.483 (10)^{abc}	0.439 (9.5)^{bcd}
17	Financial assistance	0.137 (5)^{a}	0.071 (3)^{ab}	0.189 (6.5)^{ab}	0.132 (4)^{abcd}
Kruskal-Wallis test: 'Between Constraints' χ^2_{16}		439.95**	453.35**	189.70**	27.39**

Note: 1. The indices with the same superscript alphabets in a region indicate that they are on a par with each other.
2. Values within the parenthesis are the ranks accorded to the constraints in the region
3. ** - significant at p = .01.

Analysis of the composite index of the constraints revealed no significant variation between regions. The composite index showed no significant regional variation ($\chi^2 = 0.15$). All the constraints except 'non-availability of chemical fertiliser' and 'non-availability of pesticide' and 'poor quality seedling material planted', are perceived by the farmers to be very severe in nature and/or are sustained in the farm for a long term and to a large extent in a large scale.

Conclusion

With a virtual halt in the growth of the net sown area of Kerala, the area expansion of certain crops in the state is destined to be at the expense of other crops. The two crops that exhibited a steady rise in area, namely, coconut and rubber, have scaled the peaks of their acreage at the expense of other crops, which are traditionally the chief calorie-donors of the state. Area growth is hence no substitute for productivity growth of coconut in Kerala. Not only the planners but also the farmers themselves already discerned a gap between the actual and the potential. In an attempt to map all the deterrents in the productivity growth of the crop, an analysis of the constraints encountered by the coconut cultivators to produce to the full capacity of the richly endowed soil in Kerala has been done. Data on three dimensions of the constraints (numbering seventeen), namely, the proportion of area under coconut that is plagued by the constraint, number of years since affected and severity code denoting the intensity of the constraint, are taken for the constraints analysis. Analysis of the composite index of the constraints, over the three agro-climatic zones of Kerala revealed no significant variation between them. All the constraints except 'non-availability of chemical fertiliser', 'non-availability of pesticide' and 'poor quality seedling material planted', are perceived by the farmers to be severe in nature and/or are sustained in the farm for a long period and to a large extent in a large scale.

References

Edwards, A.L. (1969), "Techniques of attitude scale construction", Vakils Feffer and Simons Pvt. Ltd., Bombay.

GoI (Government of India). 2001. Economic Survey. Ministry of Finance. Economic Division, New Delhi.

GoI. 2003. India 2003. A Reference Annual. Publications Division, Ministry of Information and Broadcasting.

GoK (Government of Kerala) 1997. Report of the Task Force on Field Crops. Ninth Five year Plan 1997-2002. State Planning Board, Thiruvananthapuram, June.

GoK 2001. Data Book on Agriculture 2000. Kerala State Planning Board, Thiruvananthapuram.

Kannan, K.P. and Pushpangadan (1990), "Dissecting agricultural stagnation in Kerala: An Analysis across crops, seasons and regions", Working Paper No. 238. Centre for Development Studies, Trivandrum.

KAU (Kerala Agricultural University) 2000. Package of Practices, Recommendations. Directorate of Extension, Mannuthy.

Lathika, M. (2002), "Productivity of Coconut Cultivation in Kerala", Ph.D. thesis submitted to Mahatma Gandhi University, Kerala.

Ohler J.G. (1999), "Modern Coconut Management, Palm Cultivation and Products."

Prakash, R. (1991), "Increasing productivity of rice in Kerala", Productivity, vol. 32, No.3.

Siegel, Sidney. (1988), "Non-parametric Statistics for Behavioural Sciences", Mac Graw Hill, Tokyo.

Singh, A.K. (1997), "Tests, Measurement and Research Methods in Behavioural Sciences",. Bharati Bhavan, Patna.

□

Success is often the result of taking a misstep in the right direction.

– Al Bernstein

Book Reviews

Total Quality Management: Principles, Practice and Cases: *by Dr. DD Sharma*, Published by Sultan Chand & Sons, priced at Rs. 325/- (soft copy), pp. 1032.

This book consists of 33 chapters/topics covering all underlying issues and interventions related to Total Quality Management (TQM). Apart from the core topics related to the definition of TQM, the tome also has the compilation of the terms commonly used in Total Quality Management practices.

The compilation is very systematic as it starts with the introduction of concepts followed by the underlying principles, various activities or issues involved with the implementation of Total Quality Management in organiations and also referral of some popular Indian case studies.

Total Quality Management incorporates the concepts of product quality, process control, quality assurance, and quality improvement. Consequently, it is the control of all transformation processes of an organisation to better satisfy customer needs in the most economical way. Total quality management is based on internal or self-control, which is embedded in each unit of the work system (technology and people). Pushing problem solving and decision-making down in the organisation allows people who do the work to both measure and take corrective action in order to deliver a product or service that meets the needs of their customer.

Managers and experts disagree about how to effectively apply TQM to their organisations. Some advise that customer satisfaction is the driving force behind quality improvement; others suggest quality management is achieved by internal productivity or cost improvement programmes. In other applications, TQM is considered a means to introduce participative management.

The Japanese, who are believed to be the pioneers in implementation of the concept of Total Quality Management, in general, concentrate on customer satisfaction with a focus on understanding customer needs and expectations.

The philosophy that Total Quality Management is customer-oriented and its goal is to satisfy the customer seems straightforward. However, the expectations and needs of the customer may not be clearly expressed or well defined and may be difficult to measure. Measurement of attitudes as well as systems is required if the ultimate appreciation of quality lies with the customer's subjective comparison as suggested by Deming and other experts.

Literature offers some clarification. Yoji Akao addressed this issue by distinguishing three basic classes of customer wants:

1. What customers say they want. Customer demands are frequently translated into specifications without exploring their meaning with regard to how the product or service will be used. Neglecting to explore how the customer intends to use the product or service can lead to poor or improper design.
2. The customer's expected quality consists of expectations the customer does not verbalize because they assume them to be evident, such as that the product must be safe. Extensive interviews may not even elicit these expectations. Yet, customers will be dissatisfied if the product or service does not meet these assumed expectations. Even so, if the expectations are built into the product, customers will hardly notice. These expectations are so pervasive that the customer takes them for granted.
3. Exciting quality consists of attributes of the product or service contributed by the supplier. The customer may not expect them as characteristics, but they recognize them as improvements and like them. For example, a car with an

electrical system that shuts off the headlights when the ignition is turned off, even when the driver forgets, has such an attribute. A customer will appreciate that safeguard many times over and appreciate the manufacturer's foresight while driving and owning the automobile.

It is suggested that all those interested to implement Total Quality Management Systems in their respective Organisations shall read this tome to get an overview of the issues involved in designing and implementing a quality improvement effort, with stress on employee involvement. If organisations are not prepared, and barriers to change are not addressed, employee involvement will be ineffective or will not last. Effective leadership, management co-operation and a long-term strategy are the factors that help to ensure the organisational support and success of these programmes.

"How to's" for getting employee involvement (E.I.) started in your organisation or improving efforts may already include a readiness assessment. It is recommended, if you haven't done so, that you arrange for a "study" to gather baseline data to identify critical needs and issues associated with your organisation's current performance and continual improvement. Such "fact finding" can lead to information that identifies gaps between current performance and that desired by management, employees and customers. Productivity improvement efforts (TQM/EI) can then be focused on the areas that will yield the maximum results for the organisation.

In addition, information can be used from this assessment to diagnose training needs and provide a baseline against which the management team can measure improvements in both skills and productivity. Failure to identify the current skills, knowledge and management style could lead to providing some training not needed by managers and employees, and neglecting to address problems that are not related to training.

Top and middle management support was the most important factor that promoted a successful implementation of employee involvement programmes. Support was demonstrated by:

- Behaviour that encouraged and responded to employee input (i.e., walk the way they talk).
- Communication of the goals of E.I. practices throughout the organisation.
- Written goals and objectives.

This tome is a comprehensive elaboration of all the aspects required from the understanding and implementation piont of view about Total Quality Management. This involves both the technical and behavioural inputs for the successful implementation of the Total Quality Management. Proper reference of psychometric instruments has also been derived at an appropriate place from the behavioural angle. The coverage of topics involves other innovative concepts too that are considered and compared closely with the Total Quality Management e.g. 6 Sigma, ISO etc. Each concept is equally elaborated with tables and figures for better understanding for the readers. The last 2 topics – ISO 9000: 2000 and Environmental Management Systems: ISO 14000 really needs commendation for the way they are presented for the laymen using the tome for the first time.

This tome, though written nicely and edited properly, is affected by a very serious shortcoming, namely proof-reading. There are instances where the idea is explained properly but the terms used in-between makes things complicated e.g. the diagram of PDCA (page 536) repeats the term "Plan". There is further requirement of mentioning and explaining various models for excellence i.e. Baldridge or European etc. in the beginning, so as to enable the readers to understand the meaning of the term "excellence" in organisations and its relationship with the concept of Total Quality Management.

This compilation is very good for the users of TQM implementation in organisations. It may also be recommended for students with "Quality" as a major subject in their study curriculum.

Rajneesh Dalal
Manager HRD
JK Papers Ltd.

Gender Role in Communication Style *by Vijai N Giri*, Concept Publishing Company, 2004, pp 127.

Communication is a highly complex process that is an essential part of human behaviour. Whether we like to admit it or not, words and facial expression form the foundation of our interpersonal and intrapersonal relationships. Effective communication is also an important tool for career enhancement. It is not just what we communicate but how we do it which is of utmost importance.

We are in the midst of a communication revolution, what with the advent of the Internet and mobile telephones. Global connectivity has never been so good and also accessibility to the communication network has become possible for the common man even in the remotest villages of India.

It is in this context that this book has considerable relevance. The author poses pertinent questions about gender role, self esteem and the communication style of the individual. This book is about both self perception and person perception, and it dwells on the role of 'individual difference variables' as mediators of communication styles.

Vijai N Giri argues that "our communication pattern with others is deeply rooted in our self-esteem." Even the way one conducts a meeting or gives a presentation communicates a lot about a person's behaviour based on their gender role. "Gender Role in Communication Style" has been divided into five chapters. Chapter one provides information of research already conducted on gender and communication, including the general observation that males are expected to be more aggressive and achievement-orientated, while females are expected to be nurturers. Research has shown that self-esteem is developed in women and men according to their experiences and their interaction with each other. In this chapter there is also a definition of "sex" as a biological factor and "gender" which evolves as a result of the socialisation process.

The three dominant communication styles are elucidated, namely noble communication which is direct and in which one feels obliged to state the truth; Socratic communication in which the individual is concerned with detail; and Reflective communication in which the individual is a warm and supportive communicator concerned with interpersonal relationships.

Chapter two describes the sample characteristics, measures and the test administration. Data was collected using the Bern Sex Role Inventory, Communication Style Profile Test, Masculine and Feminine Self-Disclosure Scale and the Rosenberg Self-Esteem scale. A sample of 415 undergraduate and post-graduate students (282 males and 133 females) was used. This chapter provides details of data collection and the test administration used.

The data has been analysed by using suitable statistics and the findings have been reported in chapter 3. This study was designed to assess the impact of gender role self-perception and self esteem on communication style. Two forms of analyses have been employed to test the hypotheses, namely Regression Analysis and the evaluation of group differences and interactions.

Regression Analysis was employed to test how far the dependent variables may be predicted from independent variables (gender role, masculine and feminine self-disclosure and self-esteem).

There is a detailed discussion of the findings in chapter 4, as well as a brief outline of the limitations of this particular research work and suggestions for future research. In chapter 5 there is a brief summary of the work in this book.

Giri's hypothesis that gender role would predict communication styles is confirmed by the regression analysis. Giri concludes that masculine individuals with high self-disclosure and high self esteem tend to have the noble communication style while 'feminine' individuals with low self-disclosure and low self esteem tend to have the reflective communication style. He refers to "masculine and feminine individuals" rather than making a distinction between men and women, on the grounds that so far no scientific research has suggested genetic traits for men which make them better managers or leaders. Giri writes, "Sex-based style differences are myths."

This study is informative but it has certain limitations that the author himself points out, namely that it is based on the respondents' self-perception of gender role and self-esteem. Further research on the discrepancy of perception of self and others in different contexts is needed. Keeping this in mind, conclusions based on this study ought to be considered with caution.

This book is useful not only for students and teachers working on the theory of interpersonal communication, but also for managers and other professionals whose professions may depend largely on the appropriate method of communication.

Payal Kumar
(MA London University)
Media Consultant
□

News & Notes

Ten Principles of IT Governance

You've invested heavily in technology, but where is the payoff? This excerpt from IT Governance, a new book published by HBS Press, distills keys to creating greater value from IT.

by Peter Weill and Jeanne W. Ross

From studying and working with hundreds of enterprises, we have distilled the lessons from many outstanding leaders into ten principles of IT governance. We intend these principles to provide leaders with a succinct summary to use as a primer, refresher, or checklist as they refine their IT governance.[1]

1. Actively design governance

Many enterprises have created disparate IT governance mechanisms. These uncoordinated mechanism "silos" result from governance by default—introducing mechanisms one at a time to address a particular need (for example, architecture problems or overspending or duplication). Patching up problems as they arise is a defensive tactic that limits opportunities for strategic impact from IT. Instead, management should actively design IT governance around the enterprise's objectives and performance goals.

Actively designing governance involves senior executives taking the lead and allocating resources, attention, and support to the process. For some enterprises, this will be the first time IT governance is explicitly designed. Often there are mature business governance processes to use as a starting point. For example, the Tennessee Valley Authority piggybacked its IT governance on its more mature business governance mechanisms, such as its capital investment process. TVA's IT governance included a project review committee, benchmarking, and selective chargeback—all familiar mechanisms from the engineering side of the business.

Not only does overall governance require active design, but each mechanism also needs regular review. Focus on having the fewest number of effective mechanisms possible. Many of the enterprises we studied had as many as fifteen different governance mechanisms, all varying in effectiveness. Fifteen mechanisms may possibly be needed but it's highly unlikely. All fifteen will certainly not be very effective, integrated, and well understood. Many enterprises with effective IT governance have between six and ten integrated and well-functioning mechanisms. One goal of any governance redesign should be to assess, improve, and then consolidate the number of mechanisms. Early in the learning cycle, mechanisms may involve large numbers of managers. Typically, as senior managers better understand IT value and the role of IT, a smaller set of managers can represent enterprise needs.

2. Know when to redesign

Rethinking the whole governance structure requires that individuals learn new roles and relationships. Learning takes time. Thus, governance redesign should be infrequent. Our recommendation is that a change in governance is required with a change in desirable behavior. For example, State Street Corporation, JPMorgan Chase, Carlson Companies, and UNICEF all changed their governance to encourage desirable behaviors resulting from significant changes in strategy. All four enterprises designed governance to achieve their desired balance of business unit autonomy and commonality. State Street, JPMorgan Chase, and Carlson were all attempting to generate more synergies. UNICEF used IT to transform its operations and improve global sharing, information management, transparency, and communication. These transformations involve many other issues besides IT and take many months to implement.

In these types of transformation, IT governance can be used as one of the levers to encourage change. For example, State Street Corporation introduced

enterprise-wide IT budgeting, encouraging a shift in perspective from the business unit to the corporation. JPMorgan Chase's buy-hold-sell process accomplished the same objective at a technology level. These governance processes communicate and enforce new desirable behaviors to facilitate organizational transformations.

3. Involve senior managers

In our study, firms with more effective IT governance had more senior management involvement. CIOs must be effectively involved in IT governance for success. Other senior managers must participate in the committees, the approval processes, and performance reviews. For many enterprises, this involvement is a natural extension of senior management's normal activities. For example, MPS-Scotland Yard used its strong existing management committee structure to improve IT governance and gain greater synergies across all its operations. The Information Management Steering Group (IMSG) is one of fourteen strategic committees that connect to the top-level executive committee. This interlocking committee structure ensures senior management attention to IT in the context of the whole enterprise.

CIOs must be effectively involved in IT governance for success.

Senior management necessarily gets involved in strategic decisions. This means that senior management is rarely concerned with the exception process. However, if an exception has strategic implications, it may reach the executive level IT Steering Committee. UPS CEO Mike Eskew explained the top management role: "At some point, if it comes to you, then you say, 'This is the answer.' It's part of our jobs to make those kinds of decisions. Our CIO, Ken Lacy, almost always has it solved by the time it gets to me."[2] In firms like UPS, senior management occasionally gets involved in exception decisions because those decisions represent strategy decisions. If the exception request escalates to the CEO, then it's no longer a technology issue. At that point it's a strategic choice.

Many senior managers are willing to be involved but are not sure where to best contribute. It's very helpful for the CIO and his or her staff to communicate IT governance on one page with a picture like the Governance Arrangements Matrix. The matrix provides a vehicle for discussing each senior manager's role and any concerns they have.

4. Make choices

Good governance, like good strategy, requires choices. It's not possible for IT governance to meet every goal, but governance can and should highlight conflicting goals for debate. As the number of tradeoffs increases, governance becomes more complex. Top-performing enterprises handle goal conflicts with a few clear business principles. The resulting IT principles reflect these business principles. Old Mutual South Africa's (OMSA) six IT principles, or "nonnegotiables," as they are called, provide a useful framework or how to use IT. The first principle, which all OMSA business units must observe, states: "The interest and needs of the Group/OMSA come first when exploiting technology or when contracting with suppliers."[3] Appropriate stakeholders must be involved in the approval process prior to contracts being signed.

Some of the most ineffective governance we have observed was the result of conflicting goals. This problem was often observed in the government sector, where directives come from many agencies. The result was confusion, complexity, and mixed messages, so the governance was ignored. The unmanageable number of goals typically arose from not making strategic business choices and had nothing to do with IT. We observed that good managers trying diligently to meet all these goals became frustrated and ineffective.

5. Clarify the exception-handling process

Exceptions are how enterprises learn. In IT terms, exceptions challenge the status quo, particularly the IT architecture and infrastructure. Some requests for exceptions are frivolous, but most come from a true desire to meet business needs. If the exception proposed by a business unit has value, a change to the IT architecture could benefit the entire enterprise. We have described the exceptions process of UPS, State Street Corporation, and other enterprises. All these exemplars have three common elements to their exceptions procedures:

1. The process is clearly defined and understood by all. Clear criteria and fast escalation encourage only business units with a strong case to pursue an exception.
2. The process has a few stages that quickly move the issue up to senior management. Thus, the process minimizes the chance that architecture standards will delay project implementation.
3. Successful exceptions are adopted into the enterprise architecture, completing the organizational learning process.

Formally approved exceptions offer a second benefit in addition to formalizing organizational learning about technology and architecture. Exceptions serve as

a release valve, relieving the enterprise of built-up pressure. Managers become frustrated if they are told they can't do something they are sure is good for business. Pressure increases and the exceptions process provides a transparent vehicle to release the frustration without threatening the governance process.

6. Provide the right incentives

There has been so much written about incentive and reward systems in enterprises that we feel the topic is well covered and understood. Nevertheless, a common problem we encountered in studying IT governance was a misalignment of incentive and reward systems with the behaviors the IT governance arrangements were designed to encourage. The typical concern: "How can we expect the governance to work when the incentive and reward systems are driving different behavior?" This mismatch is bigger than an IT governance issue. Nonetheless, IT governance is less effective when incentive and reward systems are not aligned with organizational goals.

A major governance and incentive alignment issue is business unit synergy. If IT governance is designed to encourage business unit synergy, autonomy, or some combination, the incentives of the executives must also be aligned. For example, in a large consumer products firm, the CEO wanted to increase synergies between business units to provide a single face to the small number of important customers that did business with several business units. The CEO and CIO worked together to design IT governance to align the enterprise IT assets to support the new objective. The new IT governance encouraged sharing of customer information, contact logging, pricing, and order patterns across business units. However, it was not until the business unit executives' incentive system was changed from being nearly 100 percent based on business unit performance to being 50 percent based on firm-wide performance that the new IT governance gained traction.

Avoiding financial disincentives to desirable behavior is as important as offering financial incentives. DBS Bank in Singapore does not charge for architectural assistance to encourage project teams to consult with architects. Whenever incentives are based on business unit results, chargeback can be a point of contention. Enterprises can manipulate charges to encourage desirable behavior, but chargeback pricing must be reasonable and clearly understood.

It is hard to overestimate the importance of aligning incentive and reward systems to governance arrangements. If well-designed IT governance is not as effective as expected, the first place to look is incentives.

7. Assign ownership and accountability for IT governance

Like any major organizational initiatives, IT governance must have an owner and accountabilities. Ultimately, the board is responsible for all governance, but the board will expect or delegate an individual (probably the CEO or CIO) or group to be accountable for IT governance design, implementation, and performance—similar to the finance committee or CFO being accountable for financial asset governance. In choosing the right person or group, the board, or the CEO as their designate, should consider three issues.

First, IT governance cannot be designed in isolation from the other key assets of the firm (financial, human, and so on). Thus the person or group owning IT governance must have an enterprise-wide view that goes beyond IT, as well as credibility with all business leaders.

Second, the person or group cannot implement IT governance alone. The board or CEO must make it clear that all managers are expected to contribute to IT governance as they would contribute to governance of financial or any other key asset.

Third, IT assets are more and more important to the performance of most enterprises. A reliable, cost-effective, regulation-compliant, secure, and strategic IT portfolio is more critical today than ever before. The person or group owning IT governance must understand what the technology is and is not capable of. It is not the technical details that are critical but a feel for the two-way symbiotic connection between strategy and IT.

The CIO owns IT governance in the majority of sizable firms today.[4] Other enterprises have chosen either another individual (the COO or occasionally the CEO) or a committee (say, of senior business and IT leaders) to own IT governance. We have not observed any one approach that always works best. It takes a very business-oriented and well-positioned—CIO to deliver on the first consideration and a very technically interested COO or CEO to deliver on the third. Committees have the problem of meeting only periodically and dispersing the responsibility and accountability.

Our recommendation is that the board or CEO hold the CIO accountable for IT governance performance with some clear measures of success. Most CIOs will then create a group of senior business and IT managers to help design and implement IT governance. The action of the board or CEO to appoint and announce the CIO as accountable for IT governance performance is an essential first step in raising the stakes for IT governance. Without that action, some CIOs cannot engage

their senior management colleagues in IT governance. Alternatively, the board or CEO may identify a group to be accountable for IT governance performance. This group will then often designate the CIO to design and implement IT governance.

8. Design governance at multiple organizational levels

In large multi-business unit enterprises it is necessary to consider IT governance at several levels. The starting point is enterprise-wide IT governance driven by a small number of enterprise-wide strategies and goals. Enterprises with separate IT functions in divisions, business units, or geographies require a separate but connected layer of IT governance. JPMorgan Chase has IT governance at the enterprise, division, and business unit level. Usually the demand for synergies increases at the lower levels, whereas the need for autonomy between units is greatest at the top of the organization.

The lower levels of governance are influenced by mechanisms designed for higher levels. Thus, we advocate starting with the enterprise-wide IT governance, as it will have implications for the other levels of governance. However, starting enterprise-wide is sometimes not possible for political or focus reasons, and starting at the business unit level can be practical. Assembling the governance arrangements matrixes for the multiple levels in an enterprise makes explicit the connections and pressure points.

9. Provide transparency and education

It's virtually impossible to have too much transparency or education about IT governance. Transparency and education often go together—the more education, the more transparency, and vice versa. The more transparency of the governance processes, the more confidence in the governance. Many firms like State Street Corporation use portals or intranets to communicate IT governance. State Street's portal includes under the section "IT Boards, Committees, and Councils" a description of the Architecture Committee and all the other governance bodies. The portal includes tools and resources, such as a glossary of IT terms and acronyms and the "Computer Contract Checklist." Often portals include lists of approved or recommended products. Templates for proposing IT investments complete with spreadsheets to calculate the IT business value are often available.

It is hard to overestimate the importance of aligning incentive and reward systems to governance arrangements.

The less transparent the governance processes are, the less people follow them. The more special deals are made, the less confidence there is in the process and the more workarounds are used. The less confidence there is in the governance, the less willingness there is to play by rules designed to lead to increased firm-wide performance. Special deals and nontransparent governance set off a downward spiral in governance effectiveness.

Communicating and supporting IT governance is the single most important IT role of senior leaders. The person or group who owns IT governance has a major responsibility for communication. Firms in our study with more effective governance also had more effective governance communication. The more formal vehicles for communication were the most important. For example, CIOs on average assessed their enterprises' documentation of governance processes as ineffective. However, the firms with successful IT governance had highly effective documentation. Highly effective senior management announcements and CIO offices were also important to successful governance.

When senior managers, particularly those in business units, demonstrate lack of understanding of IT governance, an important opportunity is presented. Working with managers who don't follow the rules is an opportunity to understand their objections. These discussions provide insight on whether the rules need refinement as well as a chance to explain and reinforce the governance.

10. Implement common mechanisms across the six key assets

We began the book by describing how IT governance fits into corporate governance. We contend that enterprises using the same mechanisms to govern more than one of the six key assets have better governance. For example, executive committees that address all enterprise issues including IT, such as the one at MPS-Scotland Yard, create synergies by considering multiple assets.

Recall the exercise (in Chapter 1) of listing all the mechanisms implementing each of the six key assets. Each asset may be expertly governed, but the opportunity for synergistic value is lost. For example, a firm implementing a single point of customer contact strategy must coordinate its assets to deliver that uniform experience. Just having good customer loyalty (that is, relationship assets) without the products to sell (IP assets) will drain value. Not having well-trained people (human assets) to work with customers supported by good data and technology (information and IT assets) will drain value. Not having the right buildings

and shop fronts to work from or in which to make the goods (physical assets) will drain value. Finally, not coordinating the investments needed (financial assets) will drain value.

Put this way, the coordination of the six assets seems blindingly obvious. But just glance back at your six lists of mechanisms and see how well coordinated—and more importantly, how effective—they are. Many enterprises successfully coordinate their six assets within a project but not across the enterprise via governance. In designing IT governance, review the mechanisms used to govern the other key assets and consider broadening their charter (perhaps with a subcommittee) to IT rather than creating a new, independent IT mechanism.

These ten management principles highlight many of the key findings in our work with enterprises. Attention to all of them should lead to greater value from IT. The leadership of the CIO is also critical to creating IT value.

Notes:

1. Many of the examples in this section are further descriptions or summaries of examples in earlier chapters where the sources are identified.
2. Marianne Broadbent and Peter Weill, "Effective IT Governance. By Design," Gartner EXP Premier Report, January 2003, p. 60.
3. Quotation from video of interview with Mike Eskew, Chairman and CEO of UPS, discussing IT governance an investment with Jeanne Ross and Peter Weill, MIT Sloan School of Management School Center for Information Systems Research, Feburary 2002 MIT Sloan School of Management.
4. A survey taken by one of the authors using an audience response system at a meeting of IT governance ownership: CIOs 56 percent, CEOs 8 perceent, COOs 13 percent, committee of senior IT leaders 3 percet, committee of senior business and IT leaders 13 percent. □

Peter Weill is the director of the Center for Information Systems Research (CISR) and a senior research assistant at Massachusetts Institute of Technology's Sloan School of Management.

Jeanne W. Ross is Principal Research Scientist at CISR.

Source: http://hbswk.hbs.edu.

The thing that makes me a good film-maker is the same thing that makes me open restaurants in San Francisco resorts in Belize and make wines in Napa Valley: you must be open to what presents itself.

– Francis Ford Coppola

Registered with Registrar of Newspapers REGD. NO. 4757/59

Productivity

Announces

a

Special Issue
(January–March, 2005)

on

'Food Processing Industry'