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Biotech Industry: Financing & Regulatory Framework

K.K. Tripathi

The biotechnology Industry sector is today highly innovative and technology driven. The entrepreneurs wishing to venture in this area need to explore many avenues and have to pass through various drills of regulatory and financial issues. It is worth noting that the venture capitalists have not extended liberal support to this area due to high risk despite high profit in the long run due to long gestation period. The regulatory framework has also a number of tiers through which the entrepreneurs have to pass. However, the biotech industry in India is progressing slowly but steadily making its impact in the global market. The article discusses various financial and regulatory issues, with complete information on the core group of industries involved in rDNA research and production.

K.K. Tripathi is Advisor with the Department of Biotechnology, Block-2, CGO Complex, Lodi Road, New Delhi-110003.

When historians look back at the dawn of the new millennium, they note that major scientific breakthrough of the era was the characterisation in ultimate details of the genetic instructions that make a human being. The mapping of every gene in human beings, to spell out letter-by-letter the literal thread of life, has started affecting every branch of science, humanities, commerce and industry. Bionformatics, which was envisioned to become an independent discipline and for the first time coined as "Bio-IT" (Tripathi, 2000), has played a profound role in this development.

The immediate benefit to society from the use of any technology comes from its direct application for the masses. In the present scenario there is a revolution underway in biological technologies. The enthusiasm and excitement emanating from this revolutionary process has changed the lifestyle of people in certain facets of conscious existence, encompassing health, agriculture, food, industrial products and environment. In this revolutionary process, biotechnology has played and will continue to play an important role, which practically started the world over during the late seventies. This biological revolutionary process has given the new "gene centred" view of life to society and has brought biotechnology to the forefront of scientific disciplines.

India has a strong contingent of manpower with deep knowledge in biochemistry, microbiology, immunology and various allied subjects, apart from hands-on expertise in engineering, biological and agricultural sciences. With this strength, since 1982 onwards, the Indian Government has promoted modern biotechnology in all areas of scientific endeavours starting from development of infrastructure, strengthening of extramural R&D research in Indian Institutions and generation of skilled manpower in biotechnology. India can boast to be the first country in the world to establish an independent "Department of Biotechnology" under the Ministry of Science & Technology in 1986 (Tripathi, 2002). In this department, a separate division in the

name of Product & Industry Development (PID) was created in 1998 to carry out extramural R&D projects as well as to transfer the institutionally developed technologies to industry. This division has played a key role in the development and transfer of indigenous technologies to industry. Since its existence, the Department has played a very important role, not only in the development and transfer of indigenous technologies to the industry, but also in the promotion of biotechnology R&D in the country, protection of Intellectual Property Rights and ensuring the implementation of biosafety regulatory issues during the developmental process. The Department has been reorienting its programmes from time to time in piloting and catalysing product & process technology development, its transfer, absorption and commercialisation (Sharma and Tripathi, 2000a).

In comparison to the world scenario, it is observed that in India there has been a slow but steady progress in shift and preference in the use of biological machinery for the development and production of biotech products. Taking note of the developments in biotechnology in modern times, mention may be made of Genetically Modified Organisms (GMOs) involving microbes, plants and animals providing various molecules for use in pharmaceuticals, agriculture, food as well as environmental bioremediation and management. In such developments, the quality of research & development is of utmost importance as the biotechnological applications are hardcore science based. The successful commercialisation of technologies is highly rewarding, as through such technologies the value additions may contribute from 1 to 10 or even more of the original value depending upon the biotech innovation or the product in question. The innovative biotech products, thus, have immense potential of profits and returns on investments, capable of turning the fortunes of companies in a very short span of business period. Practically speaking, the biotech industry is a high-risk-high-profit proposition requiring many innovative hurdles and stringent regulatory mechanisms.

The quality of research & development is of utmost importance as the biotechnological applications.

The knowledge of the Chief Operating Officer in such product developments is very important, as each of the components of biotech products starting from discovery to development needs scientific skills and expertise (Parthasarathi, 2001). These skills may involve biological and pharmacological elements, animal experimentation, formulation development, documentation and registration and product or process protection through patenting. Since a single individual cannot handle all the areas involved in biotech product and process development, the biotech industry is largely dependent on inter-disciplinary trained manpower with a team spirit (Ghosh, 1999). Though, such concepts are very dismal in the Indian scenario, but a shift in this direction has started with the efforts of the Department of Biotechnology and emerging biotech industries, where more and more corporate houses have started establishing their own research & development centres as well as started interactions with the academia and research institutions within the country. The role of government agencies in promoting this sunrise area becomes very important with the promulgation of various proactive policies, incentives and support to the biotech sector.

Some of the core areas of work plan in modern biotechnology include:

- Management of research and applications;
- Business development and documentation;
- Standardization of cell and tissue culture techniques;
- Purification of DNA, RNAs, proteins and enzymes;
- Cloning and amplification of genes in the same species or making transgenes;
- Stabilization of gene products;
- Standardization of separation and downstream processing methods for gene products;
- Biosafety risk assessment and risk management;
- Technology packaging;
- Technology valuation and marketing;
- Protection of Intellectual Property through patenting, trademark, copyright etc.

Financing the biotech sector

In India, several government-funding agencies offer diverse types of research grants, fellowships and financial assistance through soft loans or equity, to conduct advanced research in various fields of biotechnology and commercialise the indigenous biotechnologies. Since biotechnology has applications across industry streams, various other government ministries besides Ministry of Science & Technology, and departments and agencies

Table 1: Select biotechnology projects funded by TDB

(Rs. in million)

Enterprise	Project cost	TDB Assistance	Project
Shantha Biotechnics	252.6	85 (33 % of total cost)	Development and commercialisation of recombinant Hepatitis B Vaccine
Shantha Biotechnics	244	122 (50% of total cost)	Development and commercialisation of recombinant human interferon alpha-2b
Bharat Biotech	122.1	32.5 (about 28% of total cost)	Development and commercialisation of recombinant Hepatitis B Vaccine
Bharat Biotech	235	110 (About 47% of total cost)	Development and commercialisation of recombinant streptokinase
Mark Medicines	265.7	70 (About 26 % of total cost)	Commercialization of neutraceutical supplement – a concentrate of living lactic acid bacteria possessing high probiotic and acidogenic qualities, used for preventing the development of conditional pathogenic and enteropathogenic microflora in the intestine. (The technology has been provided by Ministry of Atomic Energy, Russian Federation)
Prathista Industries	104.6	40 (About 38 % of total cost)	Manufacture of Gluconic Acid and its salts through cost-effective fermentation process developed by Regional Research Laboratory, Jammu
Shantha Marine Biotechnologies Pvt. Ltd.	95	35 (About 37 % of cost)	Extraction of natural Carotene by setting up the production facilities for cultivation of Marine Micro-Algea Dunaliella salina in sea water with technology from ABL Biotechnologies Ltd.
Ajay Biotech (India) Ltd.	25	12.5 (50 % of total cost)	Development, scale-up and manufacture of biopesticide based on *Bacillus thruingiensi (Bt)*
SPIC Ltd.	23	11.3 (About 49 % of total cost)	Commercialization of technology for production of industrial enzymes – α-amylase and Tannase
Javeri Agro Industrial & Investment Co. Ltd	16.3	4 (About 25 % of total cost)	Manufacture of Rhizobium based biofertilizer and Trichoderma (bio-control agent)
Venkateshwara Bioproducts Pvt. Ltd.	61.2	20 (About 33 % of total cost)	Processing of corncobs for producing value added industrial products including high-energy animal feed and animal health products.

Source: Technology Development Board, DST

within them are also involved in indirectly promoting and funding biotechnology within the ambit of their activities.

For the past seventeen years, the Department of Biotechnology (DBT) under the Ministry of Science and Technology has actively promoted and accelerated the progress of biotechnology through investment in this sector and creating various foci in the country around the core scientists engaged in research in modern biology.

Substantial investments in biotechnology have been made through five-year plans of DBT for promoting R&D, human resource development, establishment of biotech facilities, and product and processes development. Since the establishment of the department during the financial year 1985-86 till March 2004, an investment of INR 15.43 billion has been made. More than 50 percent of this investment has been made in the last five years and the same is growing at the rate of, at least 25 percent per year. The central government's grants to DBT for promoting biotechnology has seen a rapid growth from INR 3.96 billion in the eighth five-year (1992-1997) plan to INR 6.22 billion in the ninth five-Year plan (1997-2002). For the tenth five-year plan (2002 to 2007) an outlay of INR 18 billion has been made with the Annual Plan 2003-2004 of INR 250 million and Annual Plan 2004-2005 with the proposed outlay of INR 360 million (Annual Reports, DBT). It is expected that by the end of the Tenth Plan total investment by the Government would exceed INR 30 billion for the promotion of basic research as well as product development in modern biology and promotion of Bio-IT, through DBT.

The Government of India, in 1996, enabled the placing of the proceeds of an existent cess on the import of technology into a fund called the Fund for Technology Development and Application and created the Technology Development Board (TDB), in the Department of Science & Technology (DST) to manage it. The Technology Development Board invests in equity capital or gives soft loans to industrial concerns, cooperatives, and other agencies, as applicable, attempting development and commercial application of indigenous technology, or adapting imported technology to wider domestic

applications. Some of the foremost biotechnology products in India such as recombinant Hepatitis-B vaccine and Interferon (Shantha Biotechnics), recombinant Hepatitis B vaccine and Streptokinase (Bharat Biotech) have been developed and commercialised with financial assistance from TDB. A list of selected biotechnology projects funded by TDB is given in Table 1.

Besides TDB, other government supported programmes for development and commercialisation of biotechnologies are Home Grown Technology (HGT) Programme under TIFAC, Technopreneur Promotion Programme (TePP), Programme Aimed at Technological Self Reliance (PATSER), all within the Ministry of Science & Technology involving DST, Department of Scientific & Industrial Research (DSIR) and DBT. Some of the new biotechnologies that have been developed with the support of the HGT programme are given in Table 2.

Table 2: Biotechnologies under home grown technology programme

S. No.	Name
1.	Gallic acid by fermentation method
2.	Lactic Acid using biotechnology
3.	Biofertilizers
4.	Prebleaching of paper pulp using enzymes
5.	Oil-zapper and xanthan gum for oil industry
6.	Isolation & characterization of probiotics
7.	Manufacture of phytase enzyme for poultry feed

Source: HGT Programmeme, DST

On the other hand, keeping in view the post-GATT era and the product patent regime, private sector investment in biotechnology has been picking up since 1997 and was particularly visible after the announcement of draft human genome sequence in the year 2000. The private sector Venture capital (VC) funding in India for biotechnology projects picked up with success stories of TDB. Currently, several VC firms such as ICICI Venture, IL&FS, Small Industries Development Bank of India (SIDBI) etc. are active in biotech venture funding. Due to several steps taken by the Government in terms of encouraging foreign investments in general, the approved FDI in biotechnology sector during 2000-2004 is estimated to be more than INR four billion involving about more than 46 FDI approvals through the Foreign Investment Promotion Board (FIPB).

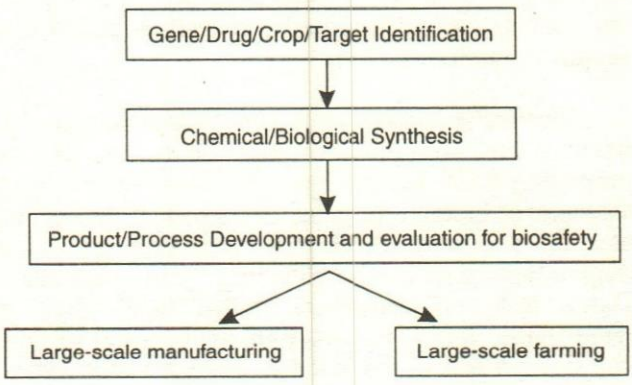
However, the current investments in various biotechnology ventures are very minor compared to other industries of the country attracting FDI. Most of the investment funds have a preference for investment in the emerging areas of biopharmaceuticals, bioinformatics (Bio-IT), and biotech services. Majority of the local and foreign investors and the funds have indicated abundance of talented, qualified, and cost-competitive human resources as the unique selling point of Indian biotechnology. Despite inadequate risk capital, lack of quality and enough entrepreneurs, lack of world-class infrastructure facilities and inability of potential investors to assess IP driven biotechnology business models and technology valuators, the conservative estimates for future investments in Indian biotechnology sector are more than USD 400 million in the next three to five years, either through FDI or deep pocketed local investors, young entrepreneurs and VCFs.

Indian Biotech Potential and Capabilities

Apart from a vast pool of trained manpower in modern biology, it has been projected that India has a large market and opportunity for biotech products and businesses comprising of biogenerics, biopharmaceuticals, agricultural, food, feed and nutrition sectors, not only for domestic consumption but also for the global market (Ghosh, 2001). The country, however, needs to invest resources in the academic research institutions and industrial biotech sectors, both for research & development as well as for infrastructure build-up. The authenticity of figures projected in the cited reference still needs validation as 2005 is fast approaching.

Since such above proposed investment measures assume utmost importance, the technology supply chain for a technologically innovative and research driven industry like biotechnology needs certain foresight by the entrepreneurs which can be illustrated through a flow chart. This may be seen in flow chart 1.

Flow Chart 1: Biotechnology Product/Process Supply Chain



Biotechnology has been considered as a "dual use" technology in the developed world, and, thus, the regulatory issues become very important before an entrepreneur ventures into the biotech sector. Under the circumstances, the understanding of regulatory framework becomes very important, not only for entrepreneurs but for investors, too. The DBT has been untiringly involved in the process of streamlining the regulatory framework from time to time, with the involvement of other concerned ministries/departments and various stakeholders.

Keeping in view the applications of biotechnology and the regulatory issues involved; the biotechnology value adding-chain is long and expensive. Going forward, an increasing number of functions that were once undertaken by Fully Integrated Pharmaceutical Companies (FIPCOs) will be sourced out to smaller, specialized entities not only in healthcare but agriculture, pharma-crops and animal and plant tissue culture sectors providing drugs, food and feed for the poor, with sustainability. It is expected that the biotechnology industry in future will become pyramidal in structure with some top biotech companies (especially Pharma-Biotech) be fully integrated manufacturing entities being supported by a large number of service providers and Contract Research Organizations (CROs) including virtual biotech incubators. (Sharma and Tripathi, 2000b).

With the advent of research in this innovative sector, several sustainable business entities have already evolved in industrialised and developed countries and the same is going to happen in India. India has the capacity and is poised to leverage many of these for international success in this field.

Government-Facilitator and Enabler: The Department of Biotechnology (DBT)

The Government of India did identify Biotechnology as a thrust area in the 80s by setting up the National Biotechnology Board in 1982, within the Ministry of Science and Technology, as an apex body to identify priorities, co-ordinate, plan for required manpower, promote integrated industrial development and large scale uses of biotech products and processes. In 1986, the National Biotechnology Board was upgraded into a full-fledged separate Department of Biotechnology under the aegis of the Ministry of Science & Technology. Since its inception, DBT has played an important role of acting as a nodal body for policy formulation and has primarily focussed on developing programmes on integrated manpower development, establishing essential infrastructure, building capacity through strengthening existing laboratories, funding research & development in medical and plant biotechnologies, imparting training to scientists in university centres and promoting bio-industries. (Tripathi, 2001a,b).

DBT's focus of developmental efforts encompasses a gamut of industry segments including genomics, proteomics, transgenics, stem cell research, and product development. Besides DBT, the key government institutes involved in promoting biotech research are - Indian Council of Medical Research (ICMR), Indian Council of Agriculture Research (ICAR), DST, DSIR, Ministry of Information Technology (MIT), Ministry of Agriculture (MOA) etc. (Tripathi, 2001,a,b).

As the government's budgetary allocation to Biotechnology has more than trebled from USD 150 million in 1987-88 to an estimated amount of USD 3 billion by the end of the Tenth Plan, the biotech industry sector is going to boom, capital-wise as well as services-wise. To promote private sector efforts in biotech research, the national budget for FY2002 did provide for 150 percent tax-deduction for R&D spending on biotechnology. The DBT has set up a Fast Track Committee that will offer a single-window processing mechanism to all biotech-related projects with an outlay of INR 1 billion (about USD 20 million) or above. This was set up under the aegis of the Financial Investment Implementation Authority (FIIA), as per the announcement of FM in the budget speech of 2002 to attract Foreign Direct Investment (FDI).

Technologies and research leads from government funded R&D-projects have been transferred to Indian industry for scale-up, validation and commercialisation.

Technology transfer

The early initiatives of transfer of biotechnology research leads, protocols and technologies to industry, have been spearheaded by Government Science & Technology (S&T) Organizations, particularly the Department of Biotechnology. The process was accelerated with the establishment of Biotechnology Consortium India Ltd. (BCIL) in 1990 to act as an agency for forging linkages between research, financial and industrial institutions and the government agencies. So far, more than 56 technologies and research leads from government funded R&D-projects have been transferred to Indian industry for scale-up, validation and commercialisation. Some of these products such as leprosy immunomodulator, which has been declared as an "orphan" drug in USA, HIV and hepatitis diagnostic kits,

Table 3: Examples of some important technologies developed through DBT support by Indian institutions and transferred to local industries

Technology	Developed by	Transferred to
Leprosy immuno-modulator	NII, New Delhi	Cadila Pharmaceuticals Ltd.
Leishmaniasis detection kit	CDRI, Lucknow	Span Diagnostics Ltd.
Western Blot kit for HIV I & II detection	CRI, Mumbai	J. Mitra & Company
Naked eye agglutination system for HIV I & II detection in whole blood	UDSC, New Delhi	Cadila Pharmaceuticals Ltd.
Hepatitis C Diagnostics (ELISA) based	ICGEB, New Delhi	X-Cyton, Bangalore
The IgM Mac ELISA kit for the detection of Dengue	NIV, Pune	Zydus Cadila, Ahmedabad
The IgM Mac ELISA kit for the detection of *Japanese Encephalitis*	NIV, Pune	Zydus Cadila, Ahmedabad
The IgM Mac ELISA kit for the detection of West Nile	NIV, Pune	Zydus Cadila, Ahmedabad
ELISA system to measure alpha-feto-protein (AFP) levels in pregnant women	NIV, Pune	Shantha Biotechnics, Hyderabad
An IgM based system for the detection of Hepatitis A virus using monoclonal/polyclonal antibodies	NIV, Pune	Bharat Biotech, Hyderabad
Urine based systems (ELISA) for the detection of Reproduction Hormones i.e. Pregnadiol Glucurinide (PDG), Esterone Glucuronide (EIG), Follicle Stimulating Hormone (FSH) and Leuteinizing Hormone (LH)	IRR, Mumbai	Zydus Cadila, Ahmedabad
A technology utilizing *Yarrowia lipolytica* expressing Hepatitis B surface and pre-S genes	University of Baroda, Baroda	Biological Evans Ltd., Hyderabad
A technology for expressing HCG using *Pichia Pastoris* system	IISc, Bangalore	Cadila Pharmaceuticals Ltd.,
Recombinant candidate anthrax vaccine	JNU and CBT, Delhi	Panacea Biotec, Delhi

Source: www.dbtindia.org.

(NII = National Institute of Immunology; CDRI = Central Drug Research Institute; CRI = Cancer Research Institute; UDSC = University of Delhi South Campus; ICGEB = International Centre for Genetic Engineering and Biotechnology; NIV = National Institute of Virology; IRR = Institute for Research in Reproduction; IISc = Indian Institute of Science; JNU = Jawaharlal Nehru University)

natural streptokinase, veterinary diagnostics are already in the market, and others are in the pipeline. The Western Blot HIV Kit developed with Indian strain and transferred to industry has already captured 90% of the market. Thus, there are success stories trickling in with the development and transfer of indigenous technologies, indicating confidence of the local industry in indigenous technologies developed through public funded institutions. Some of the examples of technologies transferred from public funded institutions to industry are listed in Table 3.

In addition to indigenous technology transfer, there have been significant developments in the country in the areas of modern biotechnology. It is noteworthy that as on date, 16 rDNA biopharmaceutical products (Table 4) have been introduced in the market, out of which five are also being produced indigenously. The first transgenic crop Bt cotton, effective against American Bollworm infection, has also been introduced conditionally for commercial cultivation since March 2002.

As on January 2004, about 250 institutions, including both from the public and private sector, are involved in activities such as research, import, manufacture or marketing of modern biotech products. Table 5 and 6 give the names of companies involved with the development and/or commercialisation of recombinant therapeutics and transgenic crops, respectively, alongwith the nature of activities and the products.

Table 4: Approved rDNA products in Indian Market

Human Insulin *(rhHu In)*
Erythropoietin *(rEPO)*
Recombinant hepatitis B vaccine *(rHepB Vac)*
Human Growth Hormone *(rHGH)*
Human Interleukin 2 *(rhIL2)*
Human Interleukin 11 *(rhIL11)*
Granulocyte Colony Stimulating Factor *(rGCSF)*
Granulocyte Macrophage Colony Stimulating Factor *(rGMCSF)*
Interferon α-2a *(rInf α-2a)*
Interferon α-2b *(rInf α-2b)*
Interferon Gamma *(rInf γ)*
Blood Factor VIII
Follicle Stimulating Hormone *(roFSH)*
Tissue Plasminogen Activator *(rTPA)*
Streptokinase *(rSK)*
rDrotrecogin-α

Table 5: Major biotechnology companies involved in the area of recombinant biopharmaceuticals

Name of the Company	Products	Nature of Work
Aktiva Biotech. Ltd., Hyderabad	r-DNA biopharmaceuticals	Research
Bharat Biotech. International Ltd., Hyderabad	r-Hepatitis B vaccine, lysostaphin, streptokinase	Research, manufacturing, marketing
Bhat Biotech. Ltd., Bangalore	r-DNA biopharmaceuticals	Research
Biocon India Ltd., Bangalore	Insulin, streptokinase, interferon, human GCSF, erythropoietin	Research, import and marketing
Biological E. Limited, Hyderabad	r-Hepatitis B vaccine	Research, in the process of initiating manufacture
Cadila Healthcare Ltd., Ahmedabad	rHepatitis B vaccine, Interferon alpha 2b	Research, import & marketing
Dabur Research Foundation, Ghaziabad	r-DNA biopharmaceuticals	Research
Dano Chemicals Ltd., Hyderabad	r-DNA biopharmaceuticals	Research
Dr. Reddy's Laboratories Ltd., Hyderabad	HIV proteins (p24, gp36, gp41), GCSF, interferon alpha 2b,r- hepatitis B vaccine	Research, manufacturing, marketing
East India Pharmaceuticals Ltd., Kolkata	r-DNA biopharmaceuticals	Research
Eli Lilly & Co., Hyderabad	α-Drotrecogin, insulin, human growth hormone	Import and marketing
Emcure Pharmaceuticals Ltd., Pune	Erythropoietin, interleukin, GMCSF	Import and marketing
Fullford India Ltd, Mumbai	Interferon	Import and marketing
Glenmark Lab. Pvt. Ltd., Mumbai	r-Human Interlukin –2; GCSF and erythropoietin	Import and marketing
Indian Immunologicals, Hyderabad	r-DNA biopharmaceuticals	Research
Indo Bioactive Labs (P) Ltd., Pune	r-DNA biopharmaceuticals	Research
INTAS Pharmaceuticals Ltd., Ahmedabad	Hepatitis B vaccine, GMCSF and interferon	Import and marketing
Johnsons & Johnsons, Mumbai	Erythropoietin	Import and marketing
Kee Pharma, New Delhi	Erythropoietin, streptokinase, GCSF	Import and marketing
L.G. Chemicals, New Delhi	Human growth hormone, erythropoietin, interferon and insulin	Import and marketing
LUPIN Limited, Mumbai	Interferon alpha 2b	Import and marketing
Medgene Biotech Pvt. Ltd., Hyderabad	r-DNA Pharmaceuticals	Research
Novo Nordisk, Mumbai	Human insulin	Import and marketing
Organon India Ltd. (earlier Infar India), Kolkata	Human follicile stimulating factor	Import and marketing
Panacea Biotec. Ltd., New Delhi	Hepatitis B vaccine, anthrax vaccine	Research, manufacture, marketing
Ranbaxy, New Delhi	Human erythropoietin, GMCSF, Interferon α-2b, hepatitis B Vaccine	Import and marketing
Serum Institute of India Ltd., Pune	FSH, Hepatitis – B	Manufacture, import & marketing
Shantha Biotechnics Pvt. Ltd., Hyderabad	Hepatitis B vaccine, interferon alpha, streptokinase	Research, manufacturing, marketing
Shasun Chemicals & Drugs Ltd., Chennai	r-DNA Pharmaceuticals	Research
Shreya Life Sciences Ltd., Mumbai	Insulin, r-human growth hormone	Import and marketing
SmithKline Beeceham	Hepatitis B vaccine combination with DPT; Hepatitis A/B combination vaccine	Import and marketing
SUN Pharmaceutical Industries Ltd., Baroda	r-DNA Pharmaceuticals	Research
Torrent Limited, Ahmedabad	Insulin	Research, import
Transgene Biotek Ltd., Hyderabad	r-DNA Pharmaceuticals	Research
USV Ltd., Mumbai	Erythropoietin, human growth hormone, platelet derived growth factor, nerve growth factor	Research
V.H. Bhagat & Co. Ltd., Mumbai	Hepatitis B vaccine, r-human growth hormone, erythropoietin	Import and marketing
Virchow Biotech. Pvt. Ltd., Hyderabad	r-DNA Biopharmaceuticals	Research, setting up manufacturing facility for biopharmaceuticals
Wyeth Lederle, Mumbai	Interleukin-2 and human tumour necrosis factor	Import and marketing
Wockhardt Limited, Aurangabad	Hepatitis B, insulin erythropoietin	Research, manufacture, marketing
Zydus Cadila Pharmaceuticals Ltd., Ahmedabad	r-erythropoietin, r-hepatitis B vaccine	Research, import and marketing

Table 6: Major biotechnology companies involved in the area of transgenic crops

Name of the Company	Products	Nature of Work
Ajeet Seeds Co. Ltd., Aurangabad	Transgenic cotton	Research, limited field trials
Ankur Seeds Pvt. Ltd., Nagpur	Transgenic cotton	Research, limited field trials
Avestha Gengraine Technologies Pvt. Ltd., Bangalore	Transgenic crops	Research
De-Nocil Crop Protection Pvt. Ltd., Mumbai	Transgenic crops	Research
Gangamai Sugar Industries Ltd., Aurangabad, Maharashtra.	Transgenic crops	Research
Hybrid Rice International Ltd., Hyderabad	Transgenic rice,	Research, limited field trials
Indo-American Hybrid Seeds (India) Pvt. Ltd., Bangalore	Transgenic tomato	Research, limited field trials
J.K. Seeds Ltd., Secunderabad	Transgenic pigeonpea	Research, limited field trials
Krishdhan Seeds Ltd., Jalana	Bt cotton	Research, limited field trials
Maharashtra Hybrid Seeds Co. Ltd., Mumbai	Bt cotton, transgenic vegetables, corn and rice	Research and production of Bt cotton
Maharashtra State Seeds Corporation Ltd., Akola	Transgenic cotton	Transgenic crops
Mahendra Hybrid Seeds Co. Ltd., Hyderabad	Transgenic cotton	Research, limited field trials
Metahelix Life Sciences Private Limited, Bangalore	Transgenic cotton, vegetabes	Transgenic crops
Monsanto India Pvt. Limited, Bangalore	Transgenic cotton, corn	Research and Field Trials
Nandi Seeds Co. Pvt. Ltd., Hyderabad, A.P.	Transgenic crops	Research
Nath Seed Company Ltd., Aurangabad	Transgenic cotton	Research, limited field trials
Nuziveedu Seeds Limited, Hyderabad	Transgenic cotton	Research
Proagro Seed Company Ltd., Gurgaon	Brassica, mustard, tomato, brinjal, cauliflower, cabbage	Research, limited field trials
Rasi Seeds (P) Ltd., Attur	Transgenic cotton	Research, limited and large scale field trials
SPIC Ltd., Chennai	Transgenic crops	Transgenic crops
Syngenta India Limited, Aurangabad	Transgenic cotton, maize	Research, limited field trials
Tulasi Seeds Private Limited, Hyderabad	Transgenic crops	Research, limited field trials

Future plans for strengthening the sector

With the creation of biotech facilities, centres of excellence and implementation of major projects in the identified areas of national relevance, a strong base of biology research in the agriculture and industry sector has been established with many expert groups in universities and national laboratories. This would be fully utilised in future programmes of crucial importance to the society during the 10th plan period and beyond. A networking approach has been followed for optimal utilization of the available infrastructure and generation of highly skilled human resources. Significant leads obtained through the mission mode programmes initiated during the 9th five year plan, especially on vaccines and herbal product development have been put for validation, clinical trials and technology development, transfer and commercialisation. Multidisciplinary and focussed disease oriented approach is being followed towards developing globally acceptable new drugs and new molecules. (Annual Reports, DBT).

For the future, the priorities of the programme for healthcare and health related biotechnologies have been made taking into consideration criteria like (a) disease burden; (b) cost effectiveness of technologies; (c) emerging and re-emerging diseases; (d) disorders because of prevalent life style and potential utilities of these technologies at the community level. The programmes have been put into two broad categories i.e. Core and Non-Core and some of the Core-Programmemes have been taken up in a mission approach.

Core Programmes

- Multi-centric, multi-investigator programmes on biotechnological approaches to emerging and re-emerging communicable diseases and non-communicable disorders.
- Development of newer technologies for affordable vaccines for Malaria, Tuberculosis, Cholera, HIV, Rabies, Rotavirus, Japanese encephalitis, Helicobacter, Filariasis etc.
- Advance research in stem cell biology and clinical

applications with a view to use these stem cells for the treatment of diseases/disorders.

- Development of cocktail diagnostics molecular tools utilizing innovative technology for infectious diseases and to develop diagnostics for screening of blood in blood banks.
- Development of new drugs through combinatorial chemistry and high screening throughput by molecular tools.
- Molecular approaches for early detection and better management of acute respiratory infections of infants and children.
- Programmeme on diarrhoeal diseases in infancy and childhood with the aim to understand disease processes at the molecular level, developing rapid and reliable diagnostic tests and genetic vaccines.
- Multi-centric programme on sequencing and molecular typing of various infectious agents, relevant to disease burden of the country.
- Molecular approaches for early detection and identifying genes responsible for progression and prognosis of oral, breast and cervical cancers with special emphasis to develop molecular markers for susceptibility/resistances to chemotherapeutic/irradiation/radiation.
- Programmemes on phage display technology for diagnostics and protein engineering.
- Molecular approaches to understand diseases like diabetes, coronary heart disease, hypertension etc.
- Molecular approaches in neuro-degenerative diseases with special reference to molecular genetics of diseases like Alzheimer's disease, Parkinson's disease and motor neuron diseases.
- Research on reproductive human health and contraception with special interest for developing a long-term strategy for immunological control of reproduction both in males and females.
- Edible vaccines for infections like cholera, hepatitis, rabies etc.

Non-Core

- Initiating molecular/genetic biotechnology tools for identification of susceptible/resistance vectors.
- New expression systems for better yields of biomolecules.
- Programmeme on prevention and cure of diseases induced for faulty diet, life style, other immunological disorders.
- Establishment of transgenic animals, facilities for strengthening bio-medical research capability.
- Alternative approaches to minimize the use of animals in bio-medical research.

Apart from this elaborated list of programmes in the healthcare system, the DBT is engaged in supporting various technology developments in the area of environment, food, feed, plant-tissue culture, industrial products like enzymes, antibiotics, amino-acids, bioremediation, drug delivery systems, as well as promoting the implementation of indigenous technologies at the grass-root level through various societal programmes like bio villages and rural development issue programmes.

Incentives for Investments in Biotechnology

The Government of India (GOI) has given attention to the biotech sector for its development and promotion. It is noteworthy that the Finance Minister in his speech of the budget 2003-2004 has brought the biotech sector at par with the IT sector in terms of incentives. The Deputy Chairman of the Planning Commission during the Knowledge Millennium-III of ASSOCHAM on Biotechnology stated, as "Biotechnology is investment intensive.....public private partnership is the best solution". This is precisely what DBT is attempting. This biotech sector, which is highly knowledge intensive, enjoys a number of benefits as on date in terms of finance and in terms of support from the GOI. Some of the incentives can be bulleted as follows:

- 100% foreign equity investments are possible in all biotech sectors not falling in the SSI sector.
- Fast track clearance route for FDI involving Rs.100 crores or more.
- Depreciation allowance on plant and machinery set-up based on indigenous technology.
- Customs duty exemption on goods imported for use in Government funded R&D projects and under EPCG programmes of the Ministry of Commerce and Industry.
- Customs and excise duty exemption to DSIR recognized Scientific and Industrial Research Organisations (SIROs).
- 150% weighed tax deduction on R&D expenditure.
- 3 years excise duty waiver on patented products.
- 100% rebate on own R & D expenditure.

- 125% rebate if research is contracted in public funded R&D institutions.
- Joint R & D projects are provided with special fiscal benefits.

In addition to the above, after the budget 2003-04 announcement by the Government of India providing biotechnology industry the same benefits information technology sector, some of the benefits can be listed as follows:

- Announcement of nil duty import up to 25 percent of export realization. It will allow the biotech industry to plough back export earnings into research. This is the single most important concession the sector has got. Previously, It was a mere 1 percent.
- Clubbed with IT and the pharmaceutical sectors for income tax purposes, another big gain is the tax holiday for new biotech companies and the higher rate of depreciation on R&D equipment.
- The biotech sector will significantly benefit from the duty relief on imported R&D equipment for clinical trials and reference standards.
- A 10-year tax holiday is available to ventures engaged in developing and /or maintaining and operating infrastructure facility.

Table 7: Sustainability of Business Entities in Biotechnology

Type of company	Characteristics
Downsized	Tightens focus to reach sustainability benchmarks with available resources.
Virtual	Outsource some or all of its critical functions to third parties/CROs
Specialized	Recognizes long value chain for biotech products and targets profitability as a specialist in some part of the value chain (e.g. Fully Integrated Development Organization)
Service	Sells research & development or manufacturing capability as a service (CRO)
Information	Sells collaborative services/support rather than final products (like Bio-IT). Does not require extensive infrastructure
Enhancement	Focus initially on developing its own product; can profit by improving existing generic or biologic product through R&D and/or manufacturing improvements
Hyper-partnered	Partners with others to reduce near zero burn-rate; eliminates impact of capital/financial markets or regulatory circles for sustainability.

Source: Deliberations at Biotech Industry Meet, 20th Jan 2004 at Hotel Maurya Sheraton, New Delhi.

Sustainability of Business Entities in Biotechnology

With the product patent regime around the corner, the Indian biotech industry environment is fast changing and a number of issues are facing the industry. Some of the issues are changing success factors and impact of high regulation and the response of players to survive in this highly regulated environment. The sustainability of various companies would depend upon various characteristics that may be the attribute of the business. In case of biotech business, various entities can be assigned to a company, which is given in Table 7.

Biotech and genomics companies around the world perform nearly a fifth of all biopharmaceutical R&D, a figure that is set to double within the next ten years. Recognizing the importance of the human genome science, it is expected that over half of the new chemical entities (NCEs) developed in the next 10 to 15 years will result from research into antibodies. Recognizing the importance of this work, the industry leaders have started actively shopping around to fill the gaps in their pipelines. Most of the biotech companies are making strenuous efforts to improve the efficiency of their R&D. For sustainability, most companies also try to close the financial gap by resorting to three traditional strategies:

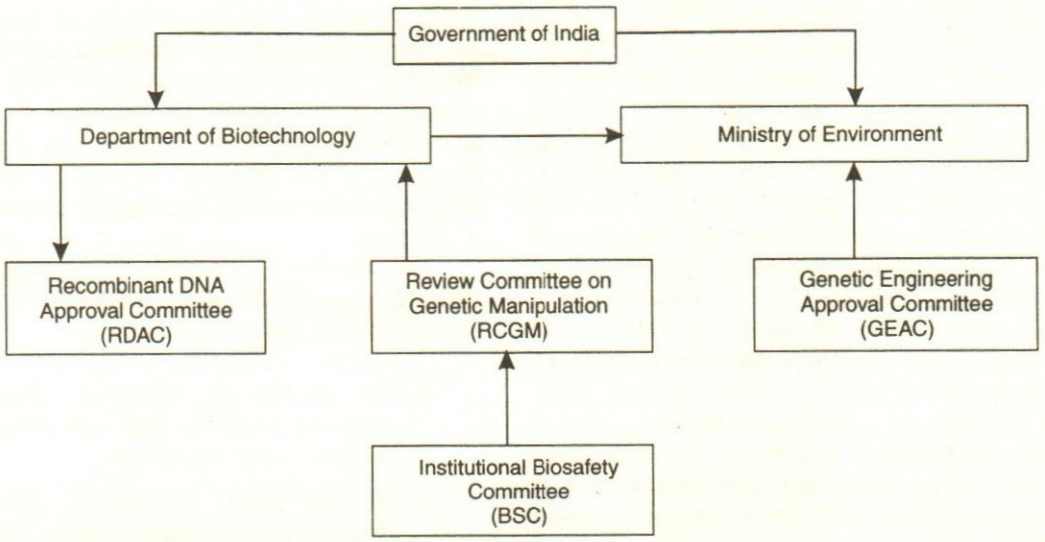
- To acquire new products from biotechnology and genomic companies – an expensive and difficult proposition, as biotech companies come of age.
- The company maximises revenues from existing products by increasing their market penetration and extending their product lines and raising prices.
- The company tries to cut costs, usually in the wake of a merger or acquisition.

These strategies can reduce the gap between what investors expect and what biotech companies deliver, but nothing concrete can be suggested for their sustainability. When it comes to stocking the pipeline, the biotech sector is in a much stronger position than what it was a short while ago. The economic downturn makes some biotech companies more vulnerable and it is likely that the biggest biotech companies will still be able to exert a considerable degree of market control.

Joint Developments – Advantage India

Indian companies have certain advantages in the area of biotechnology over their peers elsewhere in the world and there are many prospects and advantages of

Flow Chart 2: rDNA Product Approval Agencies/Bodies



joint development (Sharma & Tripathi, 2001a, b). Various advantages include:

Operational Costs: India has significantly lower-cost manpower, operational, and project capital expenditure costs vis-à-vis developed countries. It is estimated that the skilled and technical manpower costs in India are between $1/7^{th}$ to $1/10^{th}$ compared to those in developed markets.

Lower Cost Technologies: Technologies and processes for clinical trials, research & development, molecule synthesis, fine chemical production, are available at a fraction of the cost in India versus the developed markets.

Skilled Human Resources: India's educated, well-informed and trained human capital is believed to be the strongest asset for this knowledge-led industry. India has an English-speaking, highly qualified resource base in both information technology and biotechnology. With the emergence of the "reverse brain-drain" trend, there exists opportunities to tap the intellectual resources of non-resident Indians.

Centres of Excellence: Due to the dedicated efforts of the Department of Biotechnology, over the last one and a half decades, India can boast of a large network of academic institutes, universities and research laboratories undertaking basic and applied research in the field of biotechnology.

Raw Materials: India has an abundant and diverse availability of biological material in the form of plant and animal diversity and different ethnic groups for human genetic resources and is capable of conducting clinical trials, in such diverse human populations.

Regulatory Framework

The Government of India has established a well-conceived regulatory framework for approval of recombinant-DNA products for biopharmaceuticals based and genetically modified crops with independent appraisal and approval bodies to ensure high levels of human and environmental safety.

Most of the recombinant products used as drugs are within the category of "new drugs" under schedule Y of the Drugs and Cosmetics Act 1940 and Rules 1945, as amended from time to time. For the production of recombinant products, there are certain regulatory mechanisms involved under the Environment (Protection) Act, 1986 and the Rules there under (1989) as they involve the production of a GMO capable of manufacturing a particular product. Any company involved in the manufacture of a recombinant product has to follow the EPA and the Rules there under before the production of any recombinant product as a drug, food, crop or farm product. The regulatory procedure under the EPA defines competent authorities and composition of such authorities for handling of all aspects of GMOs and the products thereof. The GMOs may be microorganisms, plants and animals. Presently there are six competent authorities, which are involved in the regulatory procedure for the production of GMOs and the products thereof. (Tripathi, 2003).

Rules & Procedures for approval of GMOs and recombinant products

Since the involvement of GMOs apprehends various effects on the environment, as they may have impact on

the human and animal health, flora and fauna, if released into the environment without proper assessment, the Rules and Procedures under EPA have to be followed strictly. A GMO can be safe but it can be unsafe too depending upon the transgenes, the host organism and the environment where the GMO is being manipulated. There are examples of microorganisms, especially genetically modified viruses and bacteria, which turned virulent after genetic modification. The Rules and Procedures, which govern the handling of GMOs, have been notified vide GSR 1037(E) dated 5.12.1989 from the Union Ministry of Environment & Forests. The Rules cover all kinds of GMOs and products thereof, which are controlled commodities for handling and use in the country under the EPA. Once the product of GMO as a drug after following EPA is available then the Drugs & Cosmetics Act and Rules step in for their commercial use. The involvement of various agencies and bodies in the regulatory process is given in Flow Chart-2.

Indian EPA implementation structure for GMOs

The application of 1989 Rules are for the manufacture, import and storage of microorganisms and gene technology products; genetically engineered organisms and cells and correspondingly to any substance and products and food stuff etc. of which such cells, organisms or tissues form part; new gene technologies in addition to cell hybridisation and genetic engineering methods. As stated earlier there are six competent authorities involved in the regulation of GMOs.

The Recombinant DNA Advisory Committee (RDAC): This Committee constituted by the DBT in the Ministry of Science & Technology is to monitor the developments in biotechnology at national and international levels. The RDAC submits its recommendations from time to time that are suitable for implementation, for upholding the safety regulations in research and application of GMOs and products thereof. This Committee prepared the first Indian rDNA Biosafety Guidelines in 1990, which were adopted by the Government for conducting research and handling of GMOs within the country.

The Institutional Biosafety Committee (IBSC): This Committee is constituted by the organisations/industries involved in research with GMOs or where rDNA work is being undertaken. All IBSCs have to induct one DBT nominee for overseeing the activities and ensuring that they are in line with biosafety guidelines. Every project where rDNA technology/GMO is to be used is reported to the IBSC by the investigator, apart from the status of the results of the experiments as well as the proposed experiments to be carried out. All experiments belonging to the contained conditions can be permitted by IBSC, however, the synopsis of all such experiments has to be prepared and submitted to the Review Committee on Genetic Manipulation (RCGM). IBSC also ensures experimentation at designated locations and adherence to approved protocol. The IBSC must hold a minimum of two meetings in a year. The IBSC is also responsible for making emergency plans.

The Review Committee on Genetic Manipulation (RCGM): The RCGM under the Department of Biotechnology has the following functions:

- To review all approved ongoing research projects involving high risk category and controlled filed experiments
- To lay down procedures for restriction or prohibition, production, sale, import & use of GMOs both for research and applications
- To permit experiments with category III risks and above with appropriate containment
- To authorize imports of GMOs/ transgenes for research purposes
- To authorize small-scale/field experiments in 20 acres in multi-locations in plants and up to one crop per season with up to one acre at one site
- To undertake visits of sites of experimental facilities periodically, where projects with biohazard potentials are being pursued and also at a time prior to the commencement of the activity to ensure that adequate safety measures are taken as per the guidelines.

Genetic Engineering Approval Committee (GEAC): Genetic Engineering Approval Committee (GEAC) functions as a body under the Ministry of Environment and Forests and is responsible for approval of activities involving large scale use of hazardous microorganisms and recombinant products in research and industrial production from the environment angle.

The drugs made through GMOs would require separate approval for manufacture and use under the Indian Drugs & Cosmetics Act; the production of GMOs

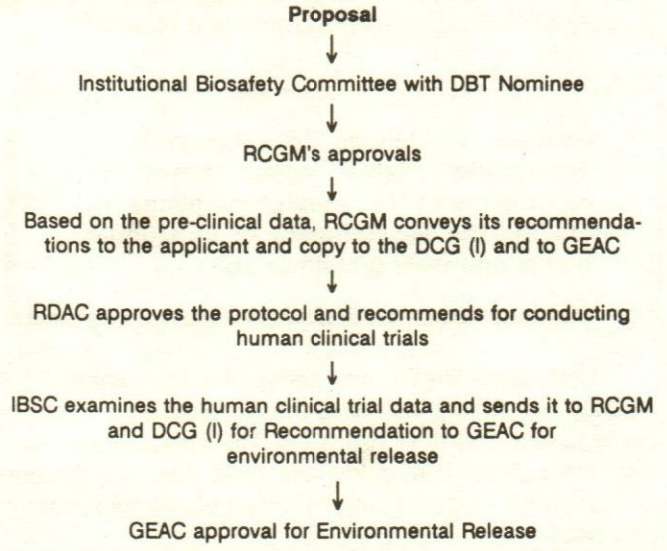
The drugs made through GMOs require separate approval for manufacture and use under the Indian Drugs & Cosmetics Act.

is also authorised under the Indian Industries (Development & Regulation) Act and therefore these clearances are also mandatory. Large-scale experiments beyond the purview of RCGM are also authorised by GEAC. GEAC can impose prohibition of the import, export, transport, manufacture, processing, use or sale of any GMOs or their products.

State Biotechnology Coordination Committee (SBCC): This Committee, headed by the Chief Secretary of the State, is constituted in each State where research and applications of GMOs are contemplated. The Committee has the powers to inspect, investigate and take punitive action in case of violation of the statutory provisions. The committee coordinates the activities related to GMOs in the State with the Central Ministries. This committee also nominates State Government representatives in activities requiring field inspection of GMOs.

District Level Committee (DLC): This Committee constituted at the district level is considered to be the smallest authoritative unit to monitor the safety regulations in installations engaged in the use of GMOs in research and applications. The District Collector who heads the Committee can induct representatives from State agencies to enable the smooth functioning and inspection of the installations with a view to ensure the implementation of safety guidelines while handling GMOs, under the Indian EPA.

Flow Chart 3: Biosafety institutional framework for the use of GMOs and recombinant products thereof, in case of rDNA Drugs, Pharmaceuticals and Therapeutics



The applicant is to follow the provisions of the Drugs Act for commercial release of the product. This shall include inspection of the production facilities, according temporary license to produce trial batches, sending products from five trial batches to CRI, Kasauli or CDL, Kolkata receiving the test report by DCG (I) and finally granting approval to manufacture and market the product.

Approval procedure for recombinant products

IBSC notes the work plan at the institutional/industrial level and based on the risk category recommends to RCGM for information/approval to conduct research. The RCGM directs the applicant to generate biosafety data on the GMO and products thereof on a case-by-case basis. After RCGM satisfies itself about the safety of the GMO/rDNA product, it recommends to the GEAC for granting approval for environmental clearance of a recombinant product. The GEAC may be is satisfied with the recommendations of the RCGM or may direct the applicant to generate more data on the safety aspects depending upon the type of the product. Based on the data available, the GEAC grants approval for environmental clearance of a product and the applicant has to follow other statutory requirements applicable to the product for commercialisation. Within the country, the recombinant drug products are either imported and marketed or manufactured and marketed after satisfying all environmental biosafety clearances and after the approval of the DCGI, taking into account the data on phase I to phase III clinical trials. The existing biosafety institutional framework for the use of GMOs and recombinant products thereof, in case of rDNA Drugs, Pharmaceuticals and Therapeutics, is given in flow chart 3.

Approval procedure for products developed indigenously

IBSC can approve experiments of the Category I and Category II risk experiments. For experiments of Category III and above risks, IBSC sends its recommendations to RCGM for approval. RCGM grants approval for conduct of experiments of Category III and above risks, and asks for progress reports periodically from the applicants/project-investigators through IBSC. Experiments concerning drugs produced from GMOs require generation of animal toxicity data. However, before such data are generated, results of at least five trial batches (including each bulk and formulation batch) are evaluated first by the IBSC and then by RCGM to ascertain if a reasonably stable process has been developed. Product acceptability criteria for both bulk and formulated materials are then fixed.

Protocols for carrying out animal toxicity studies are to be submitted for RCGM's approval. Protocol must address risks emanating from host-related contaminants as well as residual toxic chemicals used in processing. RCGM approves the conduct of animal toxicity studies; thereafter, the Animal Ethics Committee of the institu-

tion/organization has to approve the proposed protocol by the Organisation/investigator. Animal toxicity has to be carried out at least on two relevant species of animals (often, one rodent and one non-rodent species are selected). The species of animal is to be indicated in the protocol. Animal toxicity studies are carried out and IBSC meeting is convened by the institution/organization to discuss the report. If satisfactory results are obtained, protocols for Phase I, Phase II and/or Phase III studies are prepared by the institution/organization, and placed before IBSC members for approval. Phase I is needed for a new product/molecule. Phase II is needed when the dose is not known or when the dose finding has to be carried out. Straightaway Phase-III studies can be carried out if the drug is well known (like biogenerics) and the host is assessed as safe. Above documents, including protocols for human studies, are submitted by the applicants to RCGM and DCGI for approval. RCGM approves and sends its communication to the applicants and asks applicants to apply to GEAC for clearance under EPA. DCGI examines the protocol and recommends carrying out of clinical trial only after GEAC has cleared such trials first from the environmental angle. Human clinical trial/studies are completed and data relating to human safety including risks to human health are generated and data is submitted to IBSC. IBSC meeting is convened by the institution/organization for approval of the human clinical trial report. Clinical trial report is submitted to RCGM, GEAC and DCG (I). The applicant submits information in a format seeking clearance under EPA. For clearance under the Drugs Act, a separate format is used. GEAC sends the application to four or five experts including DBT, and, on the basis of the recommendations of the experts, GEAC members evaluate and approve the r-DNA drug under EPA for open environmental release, *i.e.*, for marketing. The DCG (I) has set up an expert committee for r-DNA drugs and the applicant is required to make a presentation before that committee. DCG (I) takes a decision on the basis of the recommendations of the expert committee. Both DCG (I) and GEAC can impose conditions of surveillance on the product during marketing. Marketing under EPA can be for a period of two to four years initially and this can be renewed on the basis of an application. Post-market surveillance data may be required to be generated and submitted to DCG (I) and GEAC by the applicants.

Approval procedure for rDNA products imported and marketed in India

Only those drugs that are approved in the country of origin are considered for import and marketing in India. The application is made simultaneously to the GEAC and DCG (I) in the respective formats. The application is sent by GEAC to four to five experts including DBT, seeking their evaluation/ comments before examining it in its meeting. DCG (I) also examines the report in-house as well as consults experts. GEAC may decide to direct the applicant to conduct further clinical trials if the committee has any doubt about the product in terms of evaluation of safety, lack of information on certain aspects of safety, the inadequacy of the sample size used in the evaluation etc. Phase III clinical trials may be ordered incorporating the protocol questions that address certain issues of human risks/adversary actions. If the data are found to be satisfactory by the GEAC, the latter sends its recommendations to the DCG (I) incorporating conditions that require the generation of post-market surveillance information (Phase IV data). If not approved, the GEAC directs the applicant to apply afresh after generating the necessary data with Phase III clinical trial. After receiving authorization from the GEAC, if the DCG (I) is also satisfied with the data, it grants its initial approval. Authorization for imports is issued by the DCG (I) incorporating its conditions as well as those of the GEAC, and the applicant imports and markets the drug.

Approval procedure for transgenic agriculture products

In 1998, DBT brought out separate guidelines for carrying out research in transgenic plants called the "Revised Guidelines for Research in Transgenic Plants". These also include the guidelines for toxicity and allergenicity of transgenic seeds, plants and plant parts.

Revised Guidelines for Research in Transgenic Plants cover areas of recombinant DNA research on plants including the development of transgenic plants and their growth in soil

These guidelines cover areas of recombinant DNA research on plants including the development of transgenic plants and their growth in soil for molecular and field evaluation. The guidelines also deal with import and shipment of genetically modified plants for research purposes.

The issues that are taken into consideration before authorizing field trials under contained conditions using GM plants include the potential of the transgenic plants for dissemination into the open environment such as through cross pollination, the dispersal mechanism of the pollens as well as the seeds, the presence of wild

and related species in the eco-system and the presence of other non-transgenic planting materials in the vicinity. While designing field experiments, efforts are made to maintain appropriate reproductive isolation so as to prevent the likelihood of seed setting outside the experimental plot. The transgenic plants are isolated from the gene pool represented by sexually compatible plants to prevent the escape of transgenes. Conditions are also introduced in certain cases to prevent flowering of plants. It is ensured that the genes or the genetically modified plants are not released into the environment beyond the experimental sites. Only such plants are taken into the open environment for experimentation, which have the minimum chance of unintended and uncontrolled adverse affects. The time of sowing, flowering and planting are also taken note of. Only those plants have been used in Indian trials so far for open field experiments under contained conditions, where the transgenes are considered to be safe or where the pollens are linked with imparting male sterility properties. Experiments have also been designed to study the potential for gene transfer and the consequence of transferring transgenic properties to weeds or other near relatives. The probability of pollen transfer and the natural mutation rates are conditions for computation in the experimental designs (Ghosh, 2003).

Experiments have also been designed to study the potential for gene transfer and the consequence of transferring transgenic properties to weeds.

Flow Chart 4: Steps to be followed for developing Transgenic Crops with new gene in new gene cassette

Proposal

↓

Institutional Biosafety Committee with DBT Nominee

↓

RCGM's approval for Lab & Green House Experiments & Generation of relevant data

↓

RCGM's approval for Contained open field trials & Generation of biosafety data

↓

RCGM's approval for Multi-location trials under RCGM & ICAR trials for generation of biosafety and agronomic data

↓

Large scale field trials under GEAC & ICAR Trials for generation of biosafety and agronomic data

↓

Commercialisation of seeds as per the relevant Acts & Rules

The genetic engineering experiments on plants have been grouped under three categories. Category I includes routine cloning of defined genes, defined non-coding stretches of DNA and open reading frames in defined genes in *E.coli* or other bacterial/fungal hosts which are generally considered as safe to human, animals and plants. The category II experiments include experiments carried out in lab and green house/net house using defined DNA fragments non-pathogenic to human and animals for genetic transformation of plants, both model species and crop species. Category III includes experiments having high risk where the escape of transgenic traits into the open environment could cause significant alterations in the biosphere, the ecosystem, plants and animals, by dispersing new genetic traits the effects of which cannot be judged precisely. Further, this also includes experiments conducted in green house and open field conditions having risks mentioned above.

The guidelines include complete design of a contained green house suitable for conducting research with transgenic plants. Besides, it provides the basis for generating food safety information on transgenic plants and plant parts. The general approval procedure for the transgenic crops/plants and agricultural products is given in flow chart 4. These guidelines can be accessed at the website *www.dbtindia.org.*

Conclusion

The opportunities of developing rDNA based therapeutic products and transgenic crops to feed the poor as well as other specialised products useful to the society are limitless. However, lack of a comprehensive National Biotech Policy, lack of a strategy for commercialising biotechnology, has been largely due to lesser academia-public-private industry partnership. This is also one of the reasons for non-establishment of biotech venture capital or angel venture funds. The current market size for biotechnology products is estimated to be more than 2.5 billion USD, which is expected to grow exponentially. With the approval of more GM crops, apart from Bt cotton, it is hoped that the future will provide a strong fillip to the agri-biotech business. India has many specific biotech opportunities, keeping in view the global trend in biotech business opportunities. These can be bulleted as follows:

- The drug majors in the world pay more than 20% of the revenues as royalties on licensed products.
- More than 70% of the new chemical entities (NCEs) under clinical trials and in the pipeline are rDNA products
- The small and medium sized companies have

started entering the biotech business.

- More than 25% of the R&D expenditure is outsourced by drug majors through CROs
- The R&D expenditure by drug majors, agri-business and other biotech based companies has been more than doubled in the last half decade viz., about 40 billion USD in the year 2000 from 20 billion USD in the year 1995. In the year 2005, it is expected to grow @ 7% per year.
- Bio-IT business is growing at a fast pace for drug discovery and tailor-made medicines
- There have been mergers and mega-mergers in drug majors, agri-business corporate and industrial product companies to grow bigger and bigger.
- There is an urgent need to reduce the developmental and trials costs in drugs and agri-business resulting in mergers and more private-public partnerships.

With its strength in IT professionals the bioinformatics (Bio-IT) base can be further strengthened and *'in-silico'* testing lease can be expanded, apart from emerging large number of CROs ready to be outsourced by the future global market. Several Indian companies have already started to invest in such emerging opportunities. Strand genomics is perhaps the most advanced in this new realm and are in the business of developing proprietary and customised algorthims for drug-research; SIRD-Clinpharma, a Bombay based CRO has joined hands with the US based largest clinical trial company, Covance Inc.; Clinigene International has also developed strategies to discover new "biomarkers" through clinical trial data. Thus, there are a number of examples in the drug sector. Similarly, in agri-business more than 12 crops are under genetic modification either for pest-resistance; herbicide-tolerance; nutrition improvement or stress tolerance. A number of public and private sector laboratories are engaged in such agro-business research. More than 10 varieties of Bt cotton are under large-scale field trials and may be released by the next year for northern, western, central and southern parts of India. The protein-rich potato has already gained fame as "protato".

India has been slow in approving the first transgenic crop i.e. Bt cotton, which took seven years of trials and tests. A lot appeared about the regulatory systems' working in media (Biospectrum, 2004), which was largely not positive. Despite criticism, the Indian biosafety regulatory system is one of the finest in the world. The three-tier mechanism makes it more transparent and pro-active. Maybe industries are in haste and consider the prevailing regulatory framework as "stumbling blocks". But it should be kept in mind that "biotechnology" is a "dual-use" technology and it is the duty of the regulators to be cautious and alert before problems of risk-management issues crop up. Also, the anti-GM lobby has been a deterrent in the proliferation of GM crops at a faster pace, making the regulatory framework more cautious. However, with the success of Bt cotton, it is hoped that the regulatory system would be further streamlined. The country is still in the learning process with various experiences of GM crops. But it is noteworthy that the regulatory framework makers are on the move to streamline various issues as desired by the biotech business industry.

The views expressed in the paper are those of the author based on his experience and assessments and they have nothing to do with the organisation to which he belongs.

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Bioinformatics: Challenges & Opportunities

S.C. Rastogi & Parag Rastogi

Bioinformatics is a fast emerging discipline that is conceptualizing biology in terms of molecules, DNA/RNA and proteins, and applying informatics techniques to understand and organize the information associated with these molecules. The discipline encompasses processes such as data collection, analysis, classification, integration, interpretation, modeling, visualization and prediction by using computational techniques. The focus is on new challenges posed by bioinformatics and on identifying opportunities for developing solutions that can be employed in solving biological and biomedical problems.

S.C. Rastogi is former Professor of Biology, Birla Institute of Technology & Science, Pilani. Parag Rastogi has worked in various capacities in information technology and consulting.

Biotechnology to Bioinformatics: The genesis

The modern biotechnology industry started taking shape in the late 1970s and early 1980s. At that time, the industry relied upon the early technology of molecular biology - which enabled cloning and isolation of genes. These isolated genes were used for large- scale production of the gene-encoded proteins, usually produced in small amounts by normal tissues.

Later, in the early 1990s, the first wave products of modern biotechnology were described as natural proteins and monoclonal antibodies to natural proteins. It was believed that second wave products would include nucleic acid molecules, carbohydrates, protein-based synthetic molecules, and modified cells for gene therapy. The impending major revolution driven by genomics and bioinformatics was still unseen.

Bioinformatics as a field evolved rapidly – a key reason being the initiation of the Human Genome Project (HGP), which captured the imagination of the whole scientific world and the general public. Today bioinformatics stands as the epitome of a multi-functional discipline capable of challenging the best minds in biotechnology, information technology, computer science, biophysics etc.

What is Bioinformatics?

The word "bioinformatics" is derived by combining biology and informatics. The crux of bioinformatics is that biological polymers, such as nucleic acid molecules and proteins, can be transformed into sequences of digital symbols. Only a limited number of alphabets are required to represent the nucleotide and amino acid monomers. It is the digital nature of this data that differentiates genetic data from many other types of biological data. Another key point is that the use of sequence data relies upon an underlying reductionist approach: sequence implies structure implies function. Consequently, sequence data can be treated as context-free, because a prediction of the biological sig-

nificance of a sequence can often be understood in isolation.

The Oxford English Dictionary defines bioinformatics as follows: "(Molecular) bio – informatics: bioinformatics is conceptualising biology in terms of molecules (in the sense of Physical chemistry) and applying "informatics techniques" (derived from disciplines such as applied mathematics, computer science and statistics) to understand and organize the information associated with these molecules, on a large scale. In short, bioinformatics is a management information system for molecular biology and has many practical applications".

There are several related terms. Thomas Roderick coined the word "genomics" in 1986 to describe the discipline of mapping, sequencing, and analyzing genomes. Even today, the meaning of genomics is not very clear, but there is agreement that the term refers to the systematic use of genome information, in conjunction with new experimental data, to answer biological, medical, or industrial questions.

Proteomics (coined by Marc Wilkins in 1995) is another such term. Proteomics stands for the systematic analysis of protein profiles of tissues. *Proteome* refers to all proteins produced by a species, much as the genome is the entire set of genes. Unlike the genome, the proteome varies with time and is defined as "the proteins present in one sample (tissue, organism, cell culture) at a certain point in time". Proteomics is a much bigger field than genomics. Genomics deals with one genome per organism. However, there are a large number of proteomes in an organism. Also, while the genome is a constant feature of an organism, the proteome varies with nature of tissue, the state of development, health or disease and effect of drug treatment. Genomics starts with the gene and makes inferences about its products (proteins), while proteomics begins with the functionally modified protein and works back to the gene responsible for its production.

Key factors for the Development of Bioinformatics

Humongous data

Modern molecular biology has generated a very large amount of data. It is impossible to store, analyze and maintain the data without the use of computers. Some of the data-initiated projects are discussed below.

(a) *Human genome project:* The Human Genome Project was conceived in 1986, and was widely discussed in the press and scientific community at the end of the 1980s. In the United States, the Human Genome Project officially started on October 1, 1990, as a 15-year programme to map and sequence the complete set of human chromosomes, as well as those of several model organisms. The goal of sequencing an estimated three billion base pairs of the human genome was ambitious, considering that few laboratories in 1990 had sequenced even 100,000 nucleotides.

The U.S. Department of Energy and the National Institutes of Health were the main research agencies responsible for developing and planning the Human Genome Project. Other centers around the world soon joined in the project, including the Wellcome Trust (United Kingdom). By 1993, the Human Genome Project had become an international effort, which included nine countries and the European Community. All centers had to follow certain rules e.g. that the nucleotide sequences must contain no more than one error in every 10,000 bases, which represents an accuracy of 99.99%.

A number of technnological innovations have contributed to the success of the HGP. The mapping and sequencing components of the HGP relied upon advances in technologies for constructing recombinant DNA libraries. The introduction of yeast artificial chromosomes helped the construction of complete physical maps of complex genomes. The development of bacterial artificial chromosomes also provided a means to clone large fragments (about 150,000 base pairs). Complementary DNA (cDNA) library construction was aided by refined preparations of enzymes, which have allowed the generation of longer and more authentic primary cDNA.

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The polymerase chain reaction (PCR) is considered the front-line analytical method for analyzing genomic DNA samples and constructing genetic maps. This method was invented in 1985 and over the years, incremental improvements in basic PCR technology have enhanced the power and practice of the technique.

The introduction of the first-semi-automated sequencer in 1987, and the development of *Taq* cycle sequencing in 1990, fluorescent labeling of DNA fragments generated by the Sanger dideoxy chain termination method have been the foundation of large-scale sequencing projects. Between 1970 and 1990, the number of nucleotides sequenced per year per inves-

tigator increased dramatically, reflecting the significant advancements in DNA sequencing technology.

(b) *Expressed Sequence Tag (EST) approach: focus on active sequences:* Most of the useful information about the human genome can be gained from the regions of DNA that encode proteins. Analysis of these nucleotide sequences allows elucidation of the corresponding amino acid sequences. Although this seems simple, a problem is that gene density in the human genome is exceptionally low (and only about 3% of the genome encodes proteins).

In the early 1990s, J. Craig Venter, a researcher at the National Institutes of Health of the U.S led the effort to devise a new way to find genes. Rather than taking the HGP strategy of sequencing chromosomal DNA one base at a time, Venter's group isolated mRNA molecules, copied these RNA molecules into DNA molecules, and then sequenced a part of the DNA molecules to create expressed sequence tags, or "ESTs." These ESTs could be used as handles to isolate the entire gene. Essentially, Venter's method focused on the "active" portion of the genome, responsible for producing mRNA for protein synthesis. HGP and EST-based sequencing approaches moved parallely.

Impact of Computational Biology

Bioinformatics has its roots in computational biology, a field that has been driven during the last two decades largely by the vast amounts of nucleotide sequence data generated and deposited in the public-domain databases (Garner & Pertsemlidis, 2003). At present, computational-based analyses, storage, and retrieval of mapping and sequencing data are considered among the most critical and rapidly evolving genomic-based technologies. The connection between molecular biology and computer science can be viewed as the outcome of coincidental timing. Widespread use of computers began at the same time the researchers were adopting techniques of cloning and nucleic acid sequencing.

Bioinformatics has its roots in computational biology.

After the formation of DNA and protein databases, software became available to search sequence databases. The first methods involved hunting for keyword matches and short sequence words. These approaches were followed by sophisticated pattern matching and alignment-based software. Today, genomics researchers rely upon software for a variety of activities as given below :

- Reading nucleotide sequences from electrophoresis gels
- Predicting encoded protein sequences
- Identifying primers for gene amplification
- Sequence comparison or alignment
- Database searching
- Analyzing evolutionary relatedness
- Pattern recognition
- Structure prediction

More than the conventional pattern recognition techniques, machine learning approaches, such as neural networks and hidden Markov models have been useful for characterizing large amounts of data and noisy patterns. These approaches try to identify patterns automatically from the data through a process of inference, model fitting, or learning from examples (Baldi & Brunak, 1998).

In the early 1990s, the introduction of GOPHER and WAIS (Wide Area Information Server) increased the selection of database accession schemes. However, both protocols have been widely replaced by the World Wide Web. The availability of databases eliminates the need to download and maintain local copies. Thus, a researcher could easily navigate across database entries through active hypertext cross-references with the guarantee that each retrieved piece of information was up to date. ExPASy (Expert Protein Analysis System), the first molecular biology Web server, was set up at Geneva University Hospital and University of Geneva in 1993. During the following months, most major genome databases were made accessible on World Wide Web servers throughout the world. Currently, there are, at least, 1000 large Internet-accessible databases of biological data.

Commercial Opportunities

The commercial opportunities in biotechnology have now been well documented. The emerging field of bioinformatics also has a great commercial future, especially for India with its prowess in IT and basic sciences. The Human Genome Project relies upon international cooperation and the sharing of knowledge. In this way, the rapidly growing data set of human nucleotide sequences reflects a macro-level of innovation at the international level. However, the transformation of that data into information is taking place at the national level, where govern-

ments are supporting commercialization of genomics and bioinformatics, and at the company level.

Global Effort

Various governments have taken initiatives to build capabilities in bioinformatics. Some of the government initiatives are discussed here.

U.S

Most notable of the initiatives taken by the US government agencies has been the development and planning of the Human Genome Project. The US, often held as the model for biotechnology cluster development, contains a number of genomics clusters, such as the genomics cluster in Cambridge, Massachusetts. The hub for activity is the Whitehead Institute/MIT Centre for Genome Research, which is one of the leaders in the HGP.

Japan

In Japan, the government introduced a programme to launch 1,000 new biotechnology-related companies within the next decade. This announcement was in line with the objective to produce a 25-fold expansion in Japan's biotechnology market by 2010. The first phase of the government programme, which is backed by the Ministry of International Trade and Industry, aims to increase Japan's competitiveness in the genomics field and to strengthen Japan's intellectual property position. One specific objective is to create vast databases of genomic information to provide data to Japanese research institutions and biotechnology companies for the development of products and technologies.

Genome Sciences Centre was set up by the Institute of Physical and Chemical Research, which has developed a high-speed DNA sequencer. It is anticipated that the new government programme will allow biotechnology companies to combine forces with electronics and multimedia industries.

Helix, which was established in 1996 as a joint venture between the Ministry of International Trade and Industry and ten private companies, consists of three research departments. The First Research Department combines established methods for identifying gene function with new core technologies, including the use of electro-optical devices for measurement of expression profiles, and high-throughput cloning of full-length DNA. The Second Research Department is responsible for bioinformatics and intends to have a computer system equipped with high-speed parallel processors, database servers, and graphics workstations. This department will also develop new software for the analysis of sequence data. The Third Research Department aims to develop methods to evaluate gene function and will analyze biological mechanisms through expression profiles. Thus, Helix includes in-house capabilities for gene sequencing, gene analysis, as well as hardware and software for bioinformatics. In July 1999, Helix filed patent applications for more than 6,000 full-length human cDNA clones. Helix hopes to produce an additional 20,000 full-length human cDNA clones in collaboration with other companies and research institutes.

China

China has also identified genomics as a major funding priority for biological and biomedical research. New genome centres in Shanghai and Bejiing receive funding from multiple sources, and are staffed with scientists from local hospitals and various institutes of the Chinese Academy of Sciences.

Canada

The Canadian government is implementing a national genomics initiative with the objective of propelling the country into the role of a major player in genomics. Genome Canada's directive is to coordinate Canadian genomics programmes into a network of centres to provide platform technologies and knowledge required for further research. The Canadian model of networked, geographically distinct centres builds on the successes of the U.K., European, and Swiss bioinformatics efforts.

The department of biotechnology (DBT) initiated the programme on bioinformatics way back in 1986-87.

India

Informatics is a very essential component in the biotech revolution. Ranging from reference to type-culture collections or comparing gene sequences access to comprehensive up-to-date biological information, all are crucial in almost every aspect of biotechnology.

The department of biotechnology (DBT) initiated the programme on bioinformatics way back in 1986-87. The Biotechnology Information System Network (BTIS), a division of DBT, has covered the entire country by

Table 1: PDB statistics

		Molecule Type				
		Proteins, Peptides, and Viruses	Protein/Nucleic Acid Complexes	Nucleic Acids	Carbohydrates	Total
Experimental Technology	X-ray Diffraction and others	18788	892	716	14	20410
	NMR	2923	95	565	4	3587
	Total	21711	987	1281	18	23997

Source: Rastogi, S.C. et al. (2003) "Bioinformatics : Concepts, Skills and Applications", CBS Publishers and Distributors, New Delhi, and updated from PDB web-site.

connecting to the 57 key research centres. The BTIS proposes to increase the bandwidth of the existing network and provide high-speed internet connectivity to continue with its present activities of training, mirroring of public utility packages, consideration of R&D projects and support to different research activities in this field. The DBT also proposes to bolster a proper education in bioinformatics through publication of textbooks and monographs by reputed scientists in the field. Collaboration with the industry is also poised to increase in the coming years.

Application areas of Bioinformatics

At a basic level, bioinformatics is used to organize biological data to help the researchers access information, add new information arising out of experiments and modify existing information. Fundamentally there are three types of datasets: genome sequences, macromolecular structures, and data from functional genomics experiments. Besides these datasets, bioinformatics analysis is also applied to other kinds of data, such as phylogenetic trees, metabolic pathways, the text of scientific papers, and medical information. For example, the Protein Data Bank ishttp://www.rcsb.otg/Pbd "the single worldwide repository for the processing and distribution of 3-D biological macromolecular structure data". PDB Holdings List (as on 13th January, 2004) is given in Table 1.

While the first level is aligned more to the management of large quantities of data, the second level is to develop tools and resources that aid in the analysis of data. Just the compilation and maintenance of data is a simple, but highly labour-intensive task. Curated databases are a very useful compendium of biological knowledge.

It is hence important and of great interest to biologists to analyze the data. Sequence analysis is perhaps the most popular of the applications of bioinformatics and it is not just a straightforward database search. Programmes such as FASTA (http://www.ebi.ac.uk/fasta33/) "provide sequence similarity and homology searching against nucleotide and protein databases. FASTA can be very specific when identifying long regions of low similarity especially for highly diverged sequences. One can also conduct sequence similarity and homology searching against complete proteome or genome databases using the FASTA programmes".

BLAST® (http://www.ncbi.nlm.nih.gov/BLAST)(Basic Local Alignment Search Tool) "is a set of similarity search programmes designed to explore all of the available sequence databases regardless of whether the query is protein or DNA. The BLAST programmes have been designed for speed, with a minimal sacrifice of sensitivity to distant sequence relationships. The scores assigned in a BLAST search have a well-defined statistical interpretation, making real matches easier to distinguish from random background hits. BLAST uses a heuristic algorithm that seeks local as opposed to global alignments and is therefore able to detect relationships among sequences that share only isolated regions of similarity".

The third level of bioinformatics applications is to use these tools to analyze the data and interpret the results in a biologically meaningful manner. Using bioinformatics, one can conduct global analysis of all the available data with the aim of uncovering common principles that apply across many systems and highlight features that are unique.

Comparative genomics is one of such large-scale applications using multiple sets of data involving the analysis and comparison of genomes from different species. It can be used to gain a better understanding of the evolution of species and to determine the function of genes and non-coding regions of the genome.

Bioinformatics can impact the traditional wet-lab approaches in several significant fields. The major impact

is on the data: acquisition, storage, analysis and interpretation of biological data.

Some of the bioinformatics applications are discussed briefly below:

Information search and retrieval

Information search and retrieval is one of the most powerful applications of bioinformatics. For example, PubMed (http://www.ncbi.nlm.nih.gov/PubMed/), a "service of the National Library of Medicine, provides access to over 12 million MEDLINE citations back to the mid-1960s and additional life science journals. PubMed includes links to many sites providing full text articles and other related resources".

TBALST® (http://chaos.swmed.edu/etblast/index.shtml) is an application that is used to compare a query set of sentences with the database of another text to identify the text in the database that is most similar to the query. A number of different algorithms can be used in eTBLAST. For example, eTBLAST can be used to compare an abstract in a paper, with every abstract in MEDLINE to identify papers and information of interest.

Genetics Related Applications

There are three types of computational problems in genetics:

1. Analysis of a single sequence to assess similarity with known genes.
2. Identify typical features such as binding sites or derive evolutionary relationships through phylogenetic trees.
3. Complete genome analysis to identify members of gene families, determination of the chromosomal location of the gene etc.

Sequence Comparison

One of the most useful and popular applications for the biologists is the sequence comparison or similarity search. The most popular tools for similarity search are BLAST and FASTA. These tools can perform pair-wise comparison of sequences. There are several variants of these methods. For example, there are several variants of BLAST – PSI-BLAST, PHI-BLAST, MEGABLAST, RPS-BLAST etc.

Linkage Analysis

Geneological research and linkage analysis involves the analysis of a large amount of data. Linkage analysis is used to identify the chromosomal location of genes – this has important implications in disease identification. There are several tools that can be used for linkage analysis. Many of these programmes are given at (http://linkage.rockefeller.edu/).

Phylogenetic Analysis

Phylogenetic analysis is also known as molecular taxonomy. It uses the representation of evolutionary information in the form of phylogenetic trees. There are several methods of conducting phylogenetic analysis. One of the most popular tools is PHYLIP (http://evolution.genetics.washington.edu/phylip.html).

Genomics

Genomics refers to mapping, sequencing, and analysis of genomes. This definition has now been enlarged to include the genome function also (Buchanan, 2002). Structural genomics represents the initial phase of genome analysis and leads to the construction of high-resolution genetic, physical, and transcript maps of an organism. The ultimate physical map of an organism is its complete DNA sequence. *Structural genomics* includes the following techniques and analytical tools:

- Linkage analysis
- Molecular cytogenetics
- Physical mapping
- EST sequencing
- Genome sequencing
- Genome organization

Genomics refers to mapping, sequencing, and analysis of genomes.

Functional genomics refers to the development and application of genome-wide or system-wide experimental approaches to assess gene function by making use of the information and reagents provided by structural genomics. It is characterized by high throughput experimental methodologies combined with statistical and computational analysis of the results. Functional genomics includes the following tools:

- Gene expression
- Forward genetics (begins with a mutant

phenotype, defines a gene or genes and leads to the determination of its DNA and protein sequence.)

- Reverse genetics (begins with a protein or DNA for which there is no genetic information and then works backward to make a mutant gene, ending up with a mutant phenotype gene.)
- Comparative genomics
- Proteomics
- Metabolomics

Microarrays

The transcriptional profiles of most genes within a genome can be analyzed using microarrays and quantitative analysis of microarray data. Transcriptional profile can help to generate gene expression data that can be used to define a cell type or condition. There is a huge amount of data produced in any microarray experiment and hence computational methods are essential to conduct this analysis.

Microarrays utilise the preferential binding of complementary single-stranded nucleic acid (cDNA) sequences. Microarray is built using a glass slide, on to which cDNA molecules are attached at fixed locations. There are a very large number of spots on an array, each containing a huge number of identical DNA molecules, of lengths from twenty to hundreds of nucleotides. Gene expression monitoring and SNP detection are the two most important applications of microarray technology. ArrayExpress (http://www.ebi.ac.uk/arrayexpress/) is a public repository for microarray data, which is aimed at storing annotated data.

Sequence Assembly

The sequence assembly tools were extensively used to efficiently and accurately assemble large numbers of individual sequence reads. The phred/phrap/consed suite of programmes (http://www.phrap.org/) is used to do the assembly and finishing of shotgun sequencing information. PolyPhred (http://droog.mbt.washington.edu/PolyPhred.html) is a tool integrated with these above tools and is used for comparison with fluorescence-based sequences across traces obtained from different individuals to identify heterozygous sites for single nucleotide substitutions.

Genome Annotation

There are various tools available for conducting genome annotation. The Genome Annotation Consortium (http://compbio.ornl.gov/gac/) is a multi-institution collaboration to "assist in the annotation and analysis of genome sequences by bioinformatics". Some of the popular tools for genome annotation are GRAIL, GRAILExp and Pipeline III at Genome Annotation Consortium. Genie (http://www.fruitfly.org/seq_tools/genie.html) is a tool to locate genes and it uses Hidden Markov Models (HMMs). There are several tools available at (http://www.softberry.com/).

Proteomics

Proteomics is a rapidly evolving field and there has been a very fast development in proteomics technologies like mass spectrometry for rapid and quantitative measurements of proteins in a complex mixture. This technology has led to the development of protein sequence databases and has immense applications in healthcare, drug research and diagnostics.

Pharmacogenomics

Lesko and Woodcock have given the following definition in "The Pharmacogenomics Journal" in 2002 : "the global science of using genetic information from an individual or population to inter-individual differences in pharmacokinetics and pharmacodynamics, identify responders and pharmacodynamics, identify responders and non-responders to a drug, and predict the efficacy or toxicity of a drug". This definition has been expanded to include: "molecular biology and genetics tools for the determination of the genome (DNA) or its products. Pharmacogenomics applies this information to drug design, discovery and clinical development" (Johnson, 2002).

HapMap (http://www.genome.gov/) is a genetic variation-mapping project launched by an international consortium to help identify genetic contributions to common diseases. It is "aimed at speeding the discovery of genes related to common illnesses such as asthma, cancer, diabetes and heart disease".

Drug Discovery and Computer-aided Drug Design

Drug discovery process usually starts with an analysis of binding sites in target proteins, or an identification of structural features common to active compounds. The process ends with the generation of small molecule "leads" suitable for further chemical synthetic work. This process includes analysis of drug-ligand complexes, quantitative assessment of binding interactions and pharmacophore development.

Computer-aided drug design (CADD) is a recent and emerging discipline that uses several bioinformatics tools and allied fields like chemoinformatics and combinatorial chemistry. This is a very important commercial application and has seen the introduction of tools like Quantitative Structure Activity Relationship (QSAR), structure-based design, combinatorial library design etc.

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Systems Biology

Systems biology has applications that encompass all areas of biology - including drug discovery. It is an evolving field that includes dynamic modeling of pathways and even the cell, multivariate analysis, and Bayesian networks.

Systems biology is highly dependent on experimental design like the e-cell (modeling and simulation environment for biochemical and genetic processes). NRCAM (http://www.nrcam.uchc.edu/) has developed a "general computational tool, the Virtual Cell for modeling cellular processes. This new technology associates biochemical and electrophysiological data describing individual reactions with experimental microscopic image data and their subcellular locations".

Opportunities for India

According to the Confederation of Indian Industry (CII), the global bioinformatics industry clocked an estimated turnover of $2 billion in 2000 and is expected to become $60 billion by 2005. If the industry and government work together it is possible to achieve a five percent global market share by 2005, i.e., a USD 3 billion opportunity in India. Bioinformatics generated a turnover of Rs 1,830 crore (USD 400 million) in 2002-03.

The past two years have seen many large multinational pharmaceutical companies acquiring other small companies and developing in the biosciences sector. IDC currently forecasts a compound annual growth rate (from 2001-02 to 2004-05) of about 10 percent in the spending on Information Technology by bioscience organizations. Considering the local market is generally less mature than those in the US and Europe, IDC forecasts more aggressive growth beyond 2005, as many of the organizations attempt to play "catch-up".

IDC expects IT spending in biosciences in India will cross $138 million by 2005, mainly in the areas of system clusters, storage, application software, and services. Also the government's life science focus provides a great deal of the necessary backbone to develop and deliver innovative products and technologies. This focus will also helps to build fast-growing and lucrative enterprises, attract international investment, and create additional high-value employment opportunities. Hence, the focus of the IT sector should be on products and services that align with bioscience needs. Demonstrating a true understanding of the IT requirements of biotechnology processes is the key for IT suppliers to bridge the chasm that currently exists between IT and science.

India is well placed to take the global leadership in genome analysis which has several ethnic populations that are valuable in providing information about disease predisposition and susceptibility, which in turn will help in drug discovery. However, as India lacks the records of clinical information about the patients, sequence data without clinical information will have little meaning. And, hence, partnership with clinicians is essential. The real money is in discovering new drugs for ourselves and not in supplying genetic information and data to the foreign companies, who would then use this information to discover new molecules.

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The genomic data provides information about the sequence, but it doesn't give information about the function. It is still not possible to predict the actual 3-D structure of proteins. This is a key area of work as tools to predict correct folding patterns of proteins will help drug design research substantially. India has the potential to lead if it invests in this area. Biotech and pharma companies need software expertise to write algorithms, develop software for existing algorithms, manage databases, and in the final process of drug discovery.

Some major opportunity areas for IT companies include:

- Improving content and utility of databases
- Developing better tools for data generation, capture, and annotation

- Developing and improving tools and databases for comprehensive functional studies
- Developing and improving tools for representing and analyzing sequence similarity and variation
- Creating mechanisms to support effective approaches for producing robust software that can be widely shared.

As major pharmaceutical and genome-based biotech companies invest heavily in software, Indian IT companies have a great business opportunity to offer complete database solutions to major pharmaceutical and genome-based biotech companies in the world.

Concluding Remarks

Bioinformatics is becoming increasingly important because of the rapid scale-up of traditional biochemical, biophysical and molecular characterization experiments to high-throughput levels. This has resulted in paradigm shifts in modern biology. High-throughput technologies such as DNA amplification, DNA sequencing, efficient structure determination, and monitoring of cellular processes have generated voluminous data, which needs to be integrated with existing knowledge to enhance research efforts. Bioinformatics can provide solutions to problems in structural and functional genomics, intermolecular interactions, proteomics, metabolomics, cellular regulation, molecular modeling, drug designing and drug discovery. With India's IT prowess, we have the potential to compete globally in handling the data, and in the discovery and development of genomic drugs. It is, therefore, imperative that the Government and the Universities take the initiative to train manpower to achieve the desired goals.

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Heroes and Lone Rangers are dead ducks. The real power is in capturing and utilizing the talent of diverse players to meet the organization's fundamental goals.

– Peter DiGiammarino

Phytases in Animal Productivity & Environmental Management

T. Satyanarayana, Ashima Vohra & Parvinder Kaur

This article focuses on the need for supplementing animal feeds with phytase, since this reduces the addition of inorganic phosphate, and further minimizes the phosphate load in the manure considerably, thereby mitigating environmental pollution and contributing to a cleaner world. The methodology for the production of phytase and its utility as an animal feed supplement for improving growth and phosphorus retention in monogastrics such as chicks, pigs and fish are described.

T. Satyanarayana, is Professor at the Department of Microbiology, University of Delhi, South Campus, New Delhi. Ashima Vohra is Lecturer and Parvinder Kaur is Research Fellow at Ram Lal Anand College, University of Delhi, New Delhi.

Phytic acid is an abundant plant constituent comprising 1-5% by weight of edible legumes, cereals, oil seeds, pollens and nuts. It is an organic form of phosphorus, which is chemically a myo-inositol hexakis-dihydrogenphosphate (IP6). The presence of phytates in plant foodstuffs is well documented. It is the primary source of inositol and storage form of phosphorus in plant seeds that are used as animal feed ingredients (oilseed meals, cereal grains and legumes) [Maga, 1982]. The total phosphorus and phytate-P of common poultry feedstuffs is presented in Table 1. Most foods of plant origin contain 50-80% of their total phosphorus as phytate (Harland and Morris, 1995).

The role of phytin-P in the plant was earlier speculated as a storage product. It was believed that a large amount of phosphorus was stored in the seed and it was liberated on germination and incorporated into ATP. Recent studies have established the role of inositol phosphate intermediates in the transport of materials into the cell. Their role in transport as secondary messengers and in signal transduction has also been confirmed (Berridge and Irvine, 1989).

Due to the interaction of phytic acid with other compounds, it acts as an antinutritional factor in several ways:

- Six reactive groups in the molecules of IP6 make it a strong chelating agent, which binds cations such as Ca^{2+}, Mg^{2+}, Fe^{2+}, Zn^{2+}. Under gastrointestinal pH conditions, insoluble metal phytate complexes are formed which make the metals unavailable for absorption in the intestinal tract of animals and humans (Maga, 1982).
- Phytates reduce digestibility of proteins, starch and lipids. It complexes with proteins making them less soluble. This is evidence of the fact that phytate-protein complexes are less subject

to proteolytic digestion than the same protein alone (Harland and Morris, 1995).

- The action of certain enzymes such as amylase, trypsin, acid phosphatase and tyrosinase has been shown to be inhibited by phytic acid and also by inositol pentaphosphate (Harland and Morris, 1995).

There are several methods for phytic acid removal such as cooking, autoclaving, ion exchange, elution with buffer and germination of seeds. However, the use of these methods, in most cases, leads to loss of nutritional constituents. An alternative and superior method is enzymatic treatment with phytases.

Phytase is an enzyme that hydrolyses phytic acid to myo-inositol and phosphoric acid in a stepwise manner forming myo-inositol phosphate intermediates. The research on phytase spans 87 years from its discovery by Suzuki et al. (1907) until its commercialization in Europe in 1993-1994 by Gist-Brocades. The commercialization required not only a practical use and delivery of the enzyme, but also the ability to produce the enzyme economically. The milestones in the discovery and commercialization of phytase have been described by Wodzinski and Ullah (1996).

There are two phytases as classified by the Nomenclature Committee of the International Union of Biochemistry and Molecular Biology (NC-IUBMB) in consultation with the IUPAC-IUBMB Joint Commission on Biochemical Nomenclature (JCBN): 3-phytase (EC 3.1.3.8), which hydrolyzes the ester bond at the 3 position of myo-inositol hexakisphosphate (Johnson and Tate, 1969) and, 6-phytase (EC 3.1.3.26), which hydrolyzes the ester bond at 6-position of myo-inositol hexakisphosphate (Cosgrove, 1969, p. 677).

Phytase producing microorganisms

Phytases have been reported in a number of bacteria (Aerobacter aerogenes (Enterobacter aerogenes), Bacillus subtilis, Bacillus amyloliquefaciems, Escherichia coli, Klebsiella aerogenes, Pseudomonas sp., Lactobacillus amylovorus, Klebsiella oxytoca MO-3, Selenomonas ruminantium, Mitsuokella multiacidus). Bacterial phytases are mostly cell associated with the exception of Bacillus subtilis, Lactobacillus amylovorus and Enterobacter sp.4.

The incidence of phytase production among fungi is highest in Aspergilli. Of all the organisms (plants, bacteria and fungi) surveyed, *A. niger* NRRL 3135 produces the most active extracellular phytase in corn starch (Shieh and Ware, 1968) and semisynthetic (Howson and Davis, 1983) media. Phytase was detected in whole cells in the fungi such as *Aspergillus clavatus* J239, *A. flavipes* Fla. A-14, *A. flavus, A. nidulans* QM-329, *A. niger* NRRL 67, *A. niger* P330, *Mucor* spp., *Penicillium* spp. P-320 and *Rhizopus* spp. (Casida, 1959). Recently phytases have been found in four basidiomycetous fungi: *Peniophora lycii, Agrocybe pediades, Ceriporia* sp. and *Trametes pubescens* (Lassen et al., 2001). Enzymes that are used as animal feed supplements should be able to withstand temperatures of 60 to 90 °C, which may be reached during the feed pelleting process (Wyss et al., 1998). Among the thermophilic fungi, phytase has been reported in *Thermomyces lanuginosus, Talaromyces thermophilus, Aspergillus fumigatus* and *Sporotrichum thermophile.*

Among yeasts, extracellular phytases are produced by *Schwanniomyces castellii* (Segueilha *et al.* 1992), *Arxula adeninivorans* (Sano *et al.* 1999), *Pichia spartinae* and *P. rhodanensis* (Nakamura *et al.* 2000). An intracellular phytase occurs in *Saccharomyces cerevisiae* (Nakamura *et al.* 2000) and *Pichia anomala* (Vohra and Satyanarayana 2001). In India, a cell-associated phytase of *Pichia anomala* was produced, and its applicability was tested as a supplement to chick feed.

Large-scale production of phytases

Phytases have been produced by submerged as well as solid-state fermentations. A number of physical parameters and medium constituents have a profound influence on the production of phytases.

Nearly all the microorganisms producing phytases are mesophiles with the exception of thermophilic fungi *Thermomyces lanuginosus* (Berka et al., 1998) and *Sporotrichum thermophile* (Ghosh, 1997). The optimum temperature for production of phytases from most of the microorganisms lies in the range of 25-37 °C. For phytase production the optimum pH of most bacteria and fungi is in the range between 5.0 and 7.0. There is no report of phytase production at alkaline pH.

Among the carbon sources tested, glucose has been the most preferred substrate for phytase production. Glucose was the best substrate for phytase production by *Lactobacillus amylovorus* (Sreeramulu et al., 1996) *Enterobacter* sp.4 (Yoon et al., 1996) and *Bacillus subtilis* (Kerovuo et al., 1998). Wheat bran (6%) was a good carbon source for phytase production by *Bacillus* sp. DS11 (Kim et al., 1998), whereas *Pseudomonas* sp. used myo-inositol (0.2%) as the sole carbon source, and produced phytase (Irving and Cosgrove, 1971). The source of nitrogen in the culture medium is another important parameter that influences growth and

production of enzyme. Organic form of nitrogen such as peptone has been extensively used for the production of phytase. Peptone (1%) was used in *Aerobacter aerogenes* (Greaves et al., 1967), whereas in *K. oxytoca,* it was supplemented with yeast extract (1%) (Jareonkitmongkol et al., 1997). Inorganic nitrogen source, ammonium sulfate was used for phytase production by *Pseudomonas* sp. (Irving and Cosgrove, 1971) and by *Enterobacter* sp. 4 (Yoon et al., 1996) and *S. castellii* (Lambrechts et al., 1992).

Canola meal contains 4-6% phytic acid, which reduces the nutritional value of the meal. During solid-state fermentation by *A. carbonarius*, the rates of growth, phytase production and reduction of phytic acid content in canola meal were higher in the presence of Na-oleate (Al Asheh and Duvnjak, 1995). Similarly, canola meal, Tween-80 and sodium oleate increased the rates of phytase production and hydrolysis of phytic acid as compared to the control, while Triton X-100 had a negative effect on these processes. Production of phytase by *A. niger* in SSF was influenced by the moisture content and age of the inoculum (Ebune et al., 1995). The various steps in the production of phytase in SSF are outlined in the following flow chart:

Solid media (canola meal) + distilled water + Tween 80 (0.5%)
↓
Sterilization at 121 °C for 45 min
↓
Inoculation with a phytase producer and incubation
↓
Extraction of enzyme using 2% aqueous solution of $CaCl_2.2H_2O$ by continuous shaking at 25 °C for 1h
↓
Liquid squeezed out using a double layer cheesecloth and centrifuged (5000 xg, 15 min, 4 °C)
↓
Concentration of enzyme from the clear supernatant

Yeast feeding as a supplementary feed has a long history. The application of low level of yeast first received attention in the 1950s (Panda et al., 1998). It is an excellent source of amino acids for poultry, good source of mineral and vitamin B complex, and boosts immunity levels in the system resulting in better protection against infection. Therefore, in our investigation, cell-bound phytase was produced from the yeast *Pichia anomala,* which was isolated from dried flower buds of *Woodfordia fruticosa* (Vohra and Satyanarayana, 2001). The production was optimized and the biomass was used to supplement chick feed as shown in the following flow chart.

Production medium
↓
Inoculation (1 % of a 12h old inoculum-$3x10^6$ CFU/ml)
↓
Incubation at 20 $C, 24 h, 250 rpm
↓
Harvesting of yeast biomass by centrifugation at 10,000xg for 20 min at 4$C
↓
Concentration of biomass by microfiltration followed by spray drying/lyophilization
↓
Supplementation of broiler finisher ration with yeast biomass @ 100g/7.5 kg (approx. 50 phytase units/bird/day)
↓
Recording body weight of chicks for an estimation of faecal phosphorus
↓
Comparison of body weights and phosphorus assimilation by the biomass-fed (enzyme-fed) chicks with the control

Application of phytases in animal husbandry

Enzymes are routinely employed in a myriad of industrial applications. Virtually all enzymes employed in the animal feed industry are hydrolases, which are used directly as feed additives to achieve any, or all of the following objectives (Walsh et al., 1993):

(a) Supplementation of the endogenous digestive activities of the host animal including proteases and amylases.

(b) Removal of antinutritional factors such as -glucans and phytic acid from problematic feedstuffs.

(c) To render certain nutrients more-readily available for absorption and to enhance the energy value of cheaper feed ingredients.

Plant feedstuffs are the major constituents of poultry diets. About two thirds of the phosphorus of feedstuffs of plant origin is present as phytic acid in the form of phytate. Under most dietary conditions, phytate P is unavailable to poultry (Nelson et al, 1968). In addition, phytate P chelates several important minerals and thereby reduces their availability.

Ruminant animals sustain the microflora that enzymatically release inorganic phosphorus from phytic acid. In monogastric animals, organic phosphorus accounts for the major part of the available phosphorus and consists mainly of phytates. Animals such as chickens and pigs produce little or no phytase in the

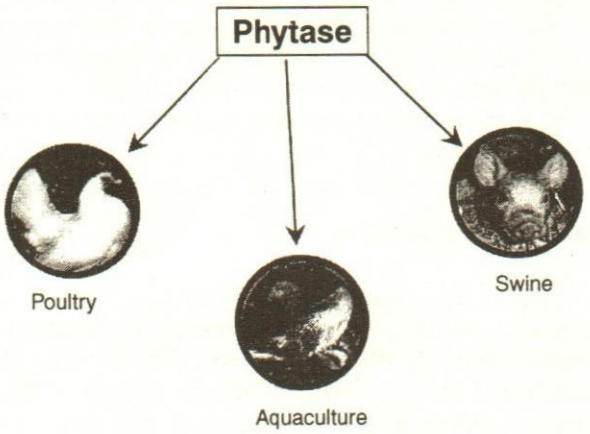

Fig. 1. Applications of Phytases in Animal Husbandry

intestine. Hence, the phytic acid phosphorus is unavailable and the phytin-P is excreted (Mullaney et al., 2000). Phytic acid present in the manure of these animals is enzymatically cleaved by soil and waterborne microorganisms. The phosphorus thus released is transported into the water bodies causing eutrophication. This results in oxygen depletion due to excessive algal growth. This lowers the dissolved oxygen in water bodies resulting in fish kills. Pretreatment of animal feed with phytases would increase the availability of inorganic phosphorus, thereby improving the nutritional status of food and also help in combating phosphorus pollution (Bali and Satyanarayana, 1999).

The availability of phosphorus can be improved by adding microbial phytase to the feed or by using phytase rich cereal diet [Fig. 1]. Supplementation of animal feeds with phytase provides swine and poultry producers with a safe and effective management tool to reduce nutrient run off by significantly reducing the amount of phosphorous excreted in the manure of the animals (Ciofalo et al., 2003). It has been estimated that the reduction or elimination of inorganic phosphorous supplementation to animal feed reduces P in the manure by above 33%, thus cutting the pollution burden by one-third (Bogar et al., 2003).

The *Alko Co.* (Finland), *Altech* (USA) and *BASF* (USA) started the industrial scale production of phytase marketed under the names Finase, Allzyme phytase, and Natuphos, respectively, and successfully utilized it in feed applications. Finase added to a corn-soybean pig diet converted one third of the unavailable phosphorus to an available form (Cromwell et al., 1993). Experiments with Allzyme and Natuphos addition to pig and chicken diets also suggested that phytase is efficacious in improving the bioavailability of phytate phosphorus for pigs (Cromwell et al., 1995a, 1995b, Yi et al., 1996, O' Quinn et al., 1997) and broilers (Yi et al., 1997).

Table 1: Total P and phytate P of common poultry feedstuffs (Tyagi et al., 1998)

Ingredients	Total P (%)	Phytate P	(%) of total P
Cereals/millets			
Maize	0.39	0.25	64
Rice	0.15	0.09	60
Wheat	0.44	0.27	61
Sorghum	0.30	0.22	73
Barley	0.33	0.20	61
Bajra	0.31	0.23	74
Oilseed meals			
Groundnut meal	0.60	0.46	77
Soybean meal	0.88	0.56	64
Cotton seed meal	0.93	0.786	82
Sunflower meal	0.90	0.45	51

Nelson et al, and his co-workers (1968) were the first to pretreat a corn-soya diet with culture filtrate containing phytases of *A. niger* and feed it to 1-day-old chicks. The chicks showed an increase in bone ash due to the phytin-P released from the dietary substances by the action of phytases. When microbial phytase was fed to low-P diets for broilers, the availability of P increased to 60%, and the amount of P in the droppings decreased by 50%. Phytase activity occurred in the alimentary tract of the chick and not in the feed prior to ingestion (Nelson et al., 1971).

When microbial phytase was added to low-P diets for broilers, the availability of P increased to over 60 % and the amount of P in the droppings decreased by 50 %. The growth rate and feed conversion ratio on the low-P diets containing microbial phytase were comparable to or even better than those obtained on control diets. The supplementation of microbial phytase to diets for growing pigs increased the apparent absorbability of P by 24%. The amount of P in the faeces was 35% lower (Simons et al, 1990).

Phytase supplementation to corn-soybean meal diets of hens had a significant effect on several production parameters: feed intake, feed conversion, and egg mass. Egg mass was significantly greater for hens supplemented with phytases A and B than for hens fed the basal diet at low (0.10%) NPP. Dry shell percentage was higher among basal diets at 0.15 and 0.25% NPP in contrast to phytase, whereas albumen and dry yolk percentages were significantly higher for

diets with phytase than for the basal diet at 0.10% NPP. Supplementation of phytase in normal, corn-soybean meal diets improved feed intake, feed conversion, and egg mass and elicited a response in shell quality and egg components at a low NP (0.1%) (Jalal and Scheideler, 2001).

Egg mass was significantly greater for hens supplemented with phytases A and B than for hens fed the basal diet at low (0.10%) NPP.

In our investigation, the yeast biomass fed chicks gained higher body weight because of which their FCR was less as compared to the control chicks. Feed conversion ratio (FCR) is defined as the ratio of feed consumed per unit gain in body weight. The data suggested that biomass fed chicks gained 510 g more weight than the control ones. The commercial value of this gain is Rs. 25.50 (at the Market rate of Rs. 50/- per kg live wt.). The overall percent gain was 90.2, which is definitely higher than 77.7% gain of the control group. Also there was better phosphorus retention in the body (29% for control and 73.6% for biomass fed) and decreased excretion of phosphorus in faeces.

Phytase interactions with supplemental inorganic phosphorus and partial rather than complete dephosphorylation of feed phytates were identified as the key factors that limit phytase efficacy in the diets of poultry. Research on enzymic cocktails that comprised phytase A, phytase B, pectinase and citric acid are reviewed. Enzymic cocktails in either soluble or intracellular form (fungal mycelium) enhanced dephosphorylation and influenced the phytate conversion rate. The enzymic cocktails improved performance and bone mineralization of broilers fed wheat-based, low phosphorus diets, close to or even above values found in birds receiving a diet high in inorganic phosphate. The enzymic cocktail strategy when applied to poultry diets also resulted in the highest values of phosphorus retention (72-75% in broilers, 77-80 % in turkeys) known in the literature (Zyta, 2001).

Canola meal, used as a feedstuff for livestock and fowl, was successfully dephytinized by *A. niger* NRRL 3135 in a solid state fermentation (Nair and Duvnjak, 1990, Nair et al., 1991, Ebune et al., 1995). Segueilha *et al.* (1993) removed phytic acid in wheat bran and glandless cotton flour using phytase from the yeast *S. castellii.*

At the close of the twentieth century, annual sales of phytase as an animal feed additive were estimated to be $500 million (Abelson, 1999). Evolution of the market for this feed additive can be attributed to a chain of events during the late twentieth century that created the need for this enzyme and provided a means for its commercial development.

Potential in aquaculture

Numerous studies have been conducted on the use of soybean meal or other plant meals in aquaculture (Mwachireya et al., 1999). By substituting low cost plant protein for a more expensive protein source, such as menhaden fishmeal, a significant cost reduction could be achieved. Feed costs constitute upto 70% of total fish production costs (Rumsey, 1993). As in poultry and hogs, fish lack an adequate digestive enzyme to effectively utilize the phytin phosphorus in the feed (Powell, 2003), thereby excreting it in the water. Therefore, phytase has been evaluated as a means of increasing the use of low-cost plant meals in the aquaculture industry, and maintaining the acceptable phosphorus levels in water. Several fish feeding studies have documented the potential value of phytase in diets containing high levels of plant feed stuffs (Robinson et al., 1996, Mwachireya et al., 1999).

Other applications

Moulds commonly used in oriental food fermentation have been examined for their ability to produce phytase. Tempeh is a popular oriental fermented food made from soyabeans inoculated by moulds (*Rhizopus oligosporus*) in the koji process.

The possible use of phytase in improving bread quality has been tested in whole wheat breads by adding different amounts of fungal phytase. The effect of phytase addition on the fermentation stage and the final bread quality was analyzed. The phytase addition shortened the fermentation period, without affecting the bread dough pH (Haros et al., 2001).

In certain locations, phytic acid and its derivatives may represent upto 50 % of the total organic phosphorus in the soil (Dalal, 1978). Findenegg and Nelemans (1993) studied the effect of phytase on the availability of phosphorus from phytic acid in the soil for maize plants. Plant growth stimulation was also reported as a result of increased rate of phytin degradation when phytase was added to the soil. The expression of phytase in the roots of transgenic plants has also been suggested to increase the availability of phosphorus to plant roots (Day, 1996, Idris et al., 2002).

Conclusions

The supplementation of animal feeds with phytase results in improved growth, better phosphorus retention in the body and decreased excretion of phosphorus in faeces.

There is also an immense potential application for phytases in aquaculture. Phytase addition to feeds improves availability of phosphorus, eliminates antinutrient phytate, and mitigates phosphorus pollution of the environment.

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Rhizobacteria in Sustainable Plant Production Systems

Bhavdish N. Johri

The zone around the plant root, known as rhizosphere, harbours a wide variety of micro-organisms that influence soil activities and plant growth. Among these, certain bacterial forms prefer to live in close proximity to plant roots and utilize the secretions released from the latter for their own multiplication and growth; these have been termed 'rhizobacteria'. They are currently a major focus of laboratory and field research since dominant populations within this gene pool show potential as biological control agents against root diseases, bioremediation agents for metal toxicity and pesticides, growth promontory agents for improved rooting and associated activities, and as agents of plant matter degradation in improved soil health. This paper shall discuss the state of art in the subject and suggest modalities for future exploitation of rhizobacterial inoculant preparations in sustainable plant production systems.

Bhavdish N. Johri is with the Department of Microbiology, G.B.Pant University of Agriculture & Technology, Pantnagar-263145, U.A.

Improved plant varieties and technological interventions have helped meet food demands of the growing population in the country. The consumption of N, P and K has increased and this has impacted major cropping systems such as rice-wheat where average yield increases of about 2 percent between 1960 to 1990, are no longer being maintained. This is a cause of concern since soil health and plant productivity are highly relevant and new interventions based on the emerging biotechnologies should also be sustainable in the long run.

Microorganisms are central to soil health and the large populations in this habitat contribute significantly towards nutrient acquisition and transport. It has been argued that intensive cropping systems which required heavy nutrient inputs have not been able to withstand the demand of the improved varieties. Thus, greater removal of nutrients than their replenishment has occurred over the years. Biological resource based technologies have appeared as viable alternative, however problems of variability, sustenance and acceptance by the end user has not been easy. In this context, microbially produced nitrogen (symbiotic free-living) is known to contribute up to 15-20 lakh tonne for crop production in the country. Such biological alternatives can improve the status of soil organic matter and microbial populations which together are soil health indicators.

Rhizosphere and Rhizobacteria

The term 'rhizosphere' was originally coined by Hiltner a century ago for the relatively large microbial population around the roots of especially the legumes; with the passage of time, this term is now freely used for the influence around plant roots in general. This zone harbours app.10 to 100-fold greater microbial populations, which suggests fierce competition for nutrients and existence of functionally and metabolically diverse species. The available nutrients include secretions,

lysates, sloughed-off cells, mucigel and polysaccharides and dead biotic material. Some of these molecules act as signals to attract, especially bacteria, which live in closer association with the roots than others. Such bacterial forms have been loosely termed "rhizobacteria".

Diversity of free-living and symbiotic bacteria

The major rhizobacteria include *Acetobacter, Arthrobacer, Azospirillum, Azotobacter, Bacillus, Flavobacter, Pseudomonas, Proteus, Rhizobium, Serratia, Xanthomnonas* and others. Depending on the functions performed, rhizobacteria have been termed differently as PGPR (Plant Growth Promotory Rhizobacteria), NPR (Nodulation Promoting Rhizobacteria), EPR (Emergence Promoting Rhizobacteria), PHPR (Plant Health Promoting Rhizobacteria), DRB (Deleterious Rhizobacteria), DRMO (Deleterious Rhizosphere Microorganisms), and YIB (Yield Increasing Bacteria). *Bacillus, Enterobacter* and *Pseudomonas* are dominant in Indian soils. Several bacterial species are known for their phosphorus solubilization potential.

Endorhizosphere

During the last few years, presence of growth promotory bacteria inside the root and shoot tissue has attracted considerable attention. Associative nitrogen fixation in the rice rhizosphere ecosystem is one of the major components of plant productivity and, therefore, endorhizospheric bacteria of this crop, in particular, have been studied. The rice root-soil interface exhibits poor aeration and low redox potential that results in the presence of both reduced and oxidized zones. As a consequence, diverse physiological groups of nitrogen-fixing bacteria live under the flooded soil ecosystem. The confirmed bacterial endophytes include, *Azoarcus* spp., *Herbaspirillum seropedicae, Pseudomonas stutzeri* A 15, *Rhizobium leguminosarum* bv. *trifolii* and *Serratia marcescens*. Endophytic forms have been reported in seeds of deep water rice varieties. Research at BHU identified *Pantoea agglomerans, Ochrobactrum anthropi, Pseudomonas fulva* and *Psuedomonas boreopolis* from the seeds of the rice variety, Jaisurya. Diversity of salt tolerant bacteria in the rhizosphere of rice comprises of *Alcaligenes xylosoxidans, Ochrobactrum anthropi, Pseudomonas aeruginosa* and *serratia marcescens*.

Associative nitrogen fixation in the rice rhizosphere ecosystem is one of the major components of plant productivity.

The endophytic *Acetobacter diazotrophicus* penetrates sugarcane roots intercellularly with the resultant colonization of xylem vessels. Endophytic habitat is looked upon with favour in future inoculant strategies since competition from the indigenous forms is minimized.

Beneficial and Deleterious forms

Gram negative forms dominate rhizobacterial population. This is achieved through various processes, the main being release of IAA, synthesis of ACC deaminase, siderophores, antibiotics, release of volatiles, and induction of systemic resistance. Bacteria capable of performing such functions are termed beneficial. Fluorescent pseudomonads (FLPs) predominate in this category. Often a single bacterial isolate can perform more than one function. In addition, the rhizobacterial population also comprises of a fraction of FLPs which is deleterious to plant growth; however, beneficial forms usually keep such populations under check in the soil environment. The deleterious action of rhizobacteria is a result of HCN production, toxins and lytic enzymes.

Community dynamics

The distribution of bacterial populations in the rhizosphere is not haphazard. A change in abiotic and / or the biotic component results in a consequent change in the community profile. Availability of molecular tools permit assessment of total community structure as also, perturbations on account of changes brought about by heavy fertilization, and other field related activities. Tools are currently available through which a molecular microbial fingerprint of an ecosystem can be made and changes followed over a sustained period of time to monitor short and long-term influences.

Plant and Soil Type Influence Diversity

Root exudation is a necessary component of plant growth development. This enriches the rhizosphere, however, the nutrient composition varies with the plant species. As a result, rhizobacterial population and community structure is a reflection of the physiological activity of a plant and any abiotic / biotic influence alters the existing equilibrium. Considering the fact that rhizobacteria exhibit strain variability, monitoring of an introduced inoculant within the indigenous community is not simple. While antibiotic resistance markers have been used successfully, vertical and horizontal movement of such genes is hazardous from the angle of biosafety considerations. To circumvent these problems, several groups in India now use molecular methods for strain differentiation.

Interactions within rhizobacteria

Among the rhizobacteria studied, FLPs are the most extensively studied group globally. In India several workers have used them in plant growth promotion and biocontrol studies. They are not only dominant in the rhizosphere but easy to cultivate; also, a great deal is known about their metabolic and genotypic versatility. Further, FLPs bring about plant growth promotion by releasing auxins, lowering the levels of ethylene through the activity of ACC deaminase (direct mechanism) , chelate iron (siderophore mediated disease suppression) and release antifungals (antibiosis mediated suppression); the latter are examples of indirect mechanism for improvement of plant health. In addition, the last decade has also seen the involvement of induced systemic resistance (ISR) in FLPs – associated plant disease suppression.

FLPs bring plant growth by releasing auxins, lowering the levels of ethylene through the activity of ACC deaminase, chelate iron and release antifungals.

Root Colonization is a Key factor

The exploitation of FLPs and other PGPR as inoculants to control plant disease, use as biofertilizers, phytostimulants and as co-inoculants for bacteria-plant based bioremediation has met with limited success at the field level on account of inconsistency and variability. In this endeavour, root colonization is the first step of establishment in the rhizosphere. There have been considerable efforts to understand long term survival rather than short term *in situ* colonization since it is the latter that determines eventual success. In our laboratory, we studied root colonization of wheat by FLPs in non-sterile soil, employing culturable population and SEM. Population level increased during the early root expansion phase, reaching a constant level, followed by a decline; on a single root, bacterial density declined from stem base to the root tip. SEM studies confirmed abundant bacterial colonization of the proximal parts of wheat root surface. More recent studies have resulted in identification of 20 genes that were induced during the rhizosphere colonization by *Pseudomonas fluorescencs;* of these, fourteen were involved in nutrient uptake, stress response or secretion processes while, the other six did not show homology to any existing sequences.

The molecular dissection of the rhizosphere shows that the association between FLPs and other rhizobacteria with the plant roots is very complex and intimate. The antifungal molecules secreted by FLPs are responsible for elimination of phytopathogens in the rhizosphere. However, it is now known that the pathogen does not like being intimidated and reacts. Smith and co-workers have reported that in *Pseudomonas fluorescens* F 113 protects the roots of sugar beet from *Pythium ultimum* by producing antifungal metabolites, the pathogen downregulates the expression of genes necessary in maintenance of rhizosphere competence of the PGPR strain. Furthermore, fusaric acid produced by *Fusarium oxysporum* can inhibit the production of diacetylphloroglucinol, an antifungal molecule of *Pseudomonas fluorescens.*

Rhizobacteria are Central to Soil Processes

Soil processes are influenced by rhizobacteria through nutrient acquisition and release, interconversions through enzymatic processes, mobilization and immobilization, influencing the physical structure through aggregation and by producing dead cell mass. Their effects are, therefore, both direct and indirect with influences on plant growth.

In a study of Alfisols and Vertisols subjected to erosion and other soil and crop related factors in Andhra Pradesh, Venkateswarlu found that the microbial population and diversity declined in the surface layer (0-10 cm) of Alfisols; this was correlated with physical and chemical properties but changes caused by seasonal erosion in cropped fields were largely reversible. Fungal population and diversity was more severely affected than actinomycetes and bacteria. This change was closely related to humic and non-humic fractions of the organic matter. Investigations of low fertility, wheat marginal fields in District Badaun, showed that at the crown root initiation stage, FLPs and siderophore-producing populations in the rhizosphere and rhizoplane were comparable but phosphate solubilizers predominated in low input-high yield field. The bacterial diversity of organically grown crops (Jhangora and Mandua) of the Central Himalayan region of Choukhutia was found to support a greater population in rhizosphere compared to bulk soil and uncultivated fields. Population of copiotrophs that required nutrient rich resource, increased with plant growth but those of oligophiles (low nutrient-demanding) declined. About 16% of a pool of 382 bacterial isolates solubilized phosphorous and produced siderophores and rhamnolipids. It appears that the long history of organic agriculture in these fields (app. 100 years), permits indigenous microbial communities to develop a strong interconversion capability for plant matter and competitive abilities, based on the release of secondary metabolities.

Growth Promotion and Biocontrol Action of Rhizobacteria

Besides building up a metabolically active population, rhizobacteria sustain the rhizosphere competition by releasing siderophores, antibiotics, HCN, IAA, polysaccharolytic enzymes, phosphatases and lipopolysaccharides. However, several PGPR release cytotoxic principles and are pathogenic agents in human disease viz., *Pseudomonas aeruginosa* and *Serratia marcescens*.

Rhizobacteria usually live in microcolonies where the transient concentration of available iron is different from than in bulk soil solution. Siderophores, that chelate iron, are secreted by rhizobacteria under iron limiting conditions. FLPs dominate the rhizobacterial population in Indian soils and produce pyoverdines. They have been studied as plant disease control agents since production of pyoverdines can create iron deficiency which is inimical to growth of phytopathogenic fungi. In a field trial conducted by us with *Pseudomonas* GRP_3 at Malegaon Farm, Sharadnagar, Dist. Pune in 1999 with groundnut, considerable reduction in iron chlorosis was achieved through seed dressing. The yield in the treated plot was 16.5 ha^{-1} compared to 11.0 q ha^{-1} in untreated control.

Many rhizobacteria secrete antifungal molecules under *in vitro* and *in situ* conditions. The major fully characterized molecules include pyrrolnitrin, pyoluteorin, tropolone, pyocyanin, phenazines and 2,4-diaacetylphloroglucino (DAPG). Among these extensive studies have been made with DAPG in disease suppressive and disease conducive soils. Besides suppression of disease through siderophore-mediated system and the release of antifungals, rhizobacteria can act through induced systemic resistance (ISR). In our lab, isolate *Pseudomonas* GRP_3 has been found to induce systemic resistance in rice against sheath blight caused by *Rhizoctonia solani;* levels of peroxidase and phenolics were higher in the diseased tissue and resulted in considerable disease reduction.

Besides the above indirect mechanisms, rhizobacteria can stimulate plant growth through the activity of the enzyme 1-amino-cyclopropane-1-carboxylate (ACC) deaminase. ACC is the immediate precursor of ethylene in plants; lowering of ACC level decreases ethylene inhibition of plant seedlings and resuls in root elongation.

Cropping Systems Perspective

Application of microbial inoculants in agro-ecosystems with a view to improve soil and plant health has been practiced for long, however, a paradigm shift in biological approaches to sustainability are dependent on consideration of cropping systems. It is estimated that in India, app. 500-700 kg major nutrients are removed annually, whereas, use of nitrogen-fixing bacteria can supplement only about 20-40 kg N ha^{-1}. Alternatives based on better residue management are being viewed with favour for maintenance of soil health. In this context, experiments carried out at PDCSR, Modipuram, utilizing cellullytic fungi for crop residue degradation showed 7.5% increase in rice-wheat productivity. There was a parallel increase in soil organic carbon and microbial biomass carbon. What is needed in such crop residue management is stable consortia derived generally from an indigenous ecosystem.

In a recently completed study of microbial dynamics and nutrient budgeting in sugarcane based cropping system at Pantnagar, we found improved microbial population in plots treated with biofertilizer (*Azotobacter* + *Pseudomonas*) + FYM. On account of higher population of siderophore-producing bacteria, especially pseudomonads, there was improved iron availability. That, nutrient management practices and cropping sequence resulted in an active biological milieu in the soil, was reflected in higher dehydrogenase activity. Biofertilizer incorporation with reduced inorganic inputs improved plant biomass and millable cane member. Completion of sugarcane-ratoon-mentha rotation with 50% inorganics + biofertilizer + FYM, resulted in greater yield of mentha oil. However, sugarcane-

Table 1: Influence of *Pseudomonas* GRP_3 as coinoculant with other rhizobacteria and organics on wheat yield*

Treatments	Mortality (%root rot)	Tillers/ sq.m	Grain yield (q/ha)
FYM + No Culture	14.54	394.0	32.86
FYM + No Culture	14.24	493.3	34.18
FYM 0 + GRP_3	0.04	642.6	37.72
FYM 5t + GRP_3	5.46	736.0	42.58
FYM 5t + Azotobacter	14.20	652.0	34.94
FYM 5t + PSB	9.33	700.0	35.63
FYM 0 + GRP_3 + PSB	5.91	848.0	41.19
FYM 5t + GRP_3 + PSB	6.02	808.0	42.58
FYM 5t + PSB + *Azotobacter*	9.01	798.6	37.40
SEM±	1.29	58.89	2.06
CD at 5%	3.78	172.73	6.08

* Based on a trial conducted at the Agricultural Research Station at Sagar, MP.

ratoon-lentil rotation was most effective in maintenance of soil health, plant productivity and accumulation of nutrients through INM strategy. (Final Report – DBT Project, 2002).

Integration of *Pseudomonas* GRP_3, an emerging biocontrol and growth promotory bacterium in our laboratory, with organics and other rhizobacteria resulted in decreased root rot and improved wheat yield in a field trial at Sagar, MP (Table 1). Evaluation of this bacterium on various other crops and soil types has yielded promising performance in various agroecosystem and soil types (Table 2).

Table 2: Influence of seed bacterization with Pseudomonas GRP_3 on grain yield of pulses in various soil types.

Treatment	Lentil (PL 406)		Mungbean (Pant-2)		Urdbean (PU-75)	
	Pant-nagar	Ujhani	Pant-nagar	Ujhani	Pant-nagar	Ujhari
Control	18.42	13.72	3.97	6.80	5.14	6.58
Rhizobium	20.28	15.26	4.04	7.27	5.48	6.82
Pseudomonas GRP_3	21.36	13.84	4.70	9.85	6.69	6.84
Rhizobium + Pseudomonas GRP_3	23.01	16.33	5.02	7.85	7.32	8.84
CD at 5%	1.19	1.04	0.42	0.30	0.57	0.22

Technological Constraints

Intensification of technological inputs in the past has resulted in an input : output ratio of the nutrients, wherein Indian soils exhibit a negative balance of about 10 million tonnes of N,P and K. The average nutrient consumption in the country is around 89 kg ha^{-1}, but in smaller pockets organics alone provide the necessary nutrient resource to the farmers. Use of organics such as biofertilizers, biopesticides, composts, green manure, crop residues, animal manures etc., has picked up momentum and organic agriculture is slowly making inroads with farmers at large. It is estimated that app. 650 million tonnes of rural compost and 16 million tonnes of urban compost requires better utilization. A recently concluded National Conference on Quality and Control of Biofertilisers at NBDC, Gbhaziabad (Jan. 2004) gave a detailed account of biofertilizers demand production capacity situation.

Interaction of Rhizobacteria with other Microorganisms

Rhizobacteria and other microorganisms occupy the rhizosphere through competition and interactions. This exerts considerable influence on the stability and sustenance of not only the indigenous useful forms but can have a direct bearing on the introduced inoculants.

Use of cultures of free-living *Azotobacter, Azospirillum* and phosphate solubilizers usually results in combined beneficial influence which is reflected in improved plant biomass and productivity. Two other major systems of interest, viz., nitrogen-fixing rhizobia and phosphorous mobilizing arbuscular mycorrhizae (AM) have been studied in detail. Saxena and Tilak at IARI, New Delhi, have summarized the findings of Indian researchers on this subject which show synergistic behaviour of *Azospirillum, Azotobactor, Acetobacter diazotorophicus* and rhizobia with resultant improvement in plant productivity in the presence/absence of other inorganic/organic inputs. Available reports show a positive, close association of rhizobacteria with AM fungi that results in fungal spread and colonization, the so-called role of a mycorrhiza-helper-bacteria (MHB). The advantage of introducing a rhizobacterium which is also, a mycorrhiza helper, takes care of several associated beneficial properties that are linked to the fungal symbiont, viz., stress tolerance, P-mobilization, metal tolerance, etc.

Rhizobacteria as Future Inoculants

The future of rhizobacteria as emerging inoculants is dependent on appropriate shelf-life, quality products and predictable field performance. Considerable effort has been made to search for new and more effective PGPRs employing the routine approach of dilution plating of rhizosphere soil and /or root macerates on to general/selective media, followed by functional analysis.

The above approach for selection of PGPRs has met with success and a fairly large gene pool of effective bacteria is available in the country. However, these selections are usually based on the screening of a rather small gene pool wherein there is every likelihood of missing out on PGPR with the most desired traits. Nautiyal at NBRI, Lucknow, has focused on the utility of a raw soil-based assay for the screening of a large gene pool of native rhizobacteria with effective root colonization potential. Subsequent potentiality is assessed through a two-stage, plant based microcosm assay. This group working at NBRI has been successful in the transfer of the sand-live soil assay method based technology to MBI International, USA and to the Dhampur Sugar Mills in U.P. Thus, more concerted efforts are necessary in the future to develop a new inoculant for sustainable soil and plant health.

Role of rDNA Techniques

Considering the fact that complete genome of *Pseudomonas aeruginosa* and *Pseudomonas fluorescens* is now available, the application of *Pseudomonas* in biocontrol of phytopathogenic fungi, in particular, has been reassessed. In wheat, maize and other crops, use of modern tools show that a large proportion of *Pseudomonas* population in the rhizosphere of wheat (– 15%) produces the antifungal metabolite, 2,4-diacetylphloraglucinol. Our experience with pseudomonads recovered from wheat rhizosphere in Dist. Badaun, however, shows that only a small fraction of FLPs produce DAPG. Considering, however, the role played by DAPG and other antifungals in disease control, future emphasis shall be placed on reprogramming of gene regulation in order to achieve better coordination for production of antifungals to formulate targeted inoculants.

Technological Inputs

Researches on PGPR in India and elsewhere have met with limited success on the technological and product formulation front. This relates to inherent variability of PGPR with respect to the influence of plant and soil type on their performance as also product acceptance in the market. For example, the USDA Web Site lists availability of no more than ten *Pseudomonas*-based commercial products on account of inconsistent field behaviour. Among these, dry powered products have been preferred globally on account of ease in transport. Most formulations in India are dry charcoal, lignite based preparations, which result in drying of cells and consequent loss of cell number and quality on storage. Alternate formulations and inoculant delivery systems which provide better nutrient environment and moisture availability for cell proliferation and release of desired secondary metabolites, are of prime significance. This could mean applying of amendments to already available preparations viz., FYM along with charcoal or similar inert carrier material. Some manufacturers in India are now producing liquid formulations to mitigate these problems, however, their performance will require appropriate long-term field evaluation.

The assessment of PGPR-based preparations on non-target organisms is an area where little, if any, work has been done by Indian researchers. The reasons are three fold - one, that many a PGPR preparation tested in India have been used for plant growth promotion activity, presuming that biocontrol action is not inherent in such an exercise; two, that a biofertilizer is not required to be registered on the lines of pesticides / insecticides; three, the guidelines issued by the government for safety assessment of genetically modified organisms (GMOs) do not apply to naturally developed strains. However, in doing so, a point has been left out that many a PGPR, FLPs and others, including bacilli, exhibit several properties in one strain and, therefore, what is being considered as growth promontory, is also endowed with antifungal metabolites, siderophores, HCN or lytic enzymes. While considerable environmental concern and discussion of pesticides and their influence on non-target organisms has been made, assessment of PGPR-based preparations on non-target organisms was not a subject of intensive discussion until recently. Most PGPR show a multitude of properties that are expressed individually as also collectively; among these, release of antifungal molecules and hydrolytic enzymes could be inhibitory to beneficial forms living around the roots such as arbuscular mycorrhizal (AM) fungi. Modern tools are now used to examine such subtle changes that could result in considerable alternation in the biological equilibrium with repeated inoculation of PGPR in the field. Release of a new inoculant would, therefore, require a critical assessment of processes in the rhizosphere as a result of introduction of a product/ formulation. Current European Union regulations make it mandatory for such a product to provide data on non-target organisms prior to registration.

Conclusion

Rhizosphere of plant species is a unique ecosystem which harbours a multitude of microorganisms. Some of these show a close relationship to the root zone on account of availability of nutrients and other yet unknown benefits, and these have been termed, rhizobacteria. One such group is that of fluorescent pseudo- monads which are able to provide direct and /or indirect benefits and help improve soil and plant health. Other PGPRs such as *Azotobacter, Azosprillium, Enterobacter* and others have been tested in various crop systems to improve plant health and productivity. Scientific selection of promising PGPR is necessary to check the problems associated with variable field performance, improved shelf-life of the product and acceptability by the farming community.

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How can one individual solve the problems of the world? Problems can only be solved if one is part of a team.

– Nelson Mandela

Feature

Information Technology, Interim Reports and Corporate Governance in India

V.K. Vasal

Accountability through transparency is an important part of a typical corporate governance model. And, IT, as a tool, has now enabled businesses, particularly the publicly traded companies, to supply information to varied 'stakeholders' with speed, efficiency and (perhaps) greater degree of reliability. The primary objective of the present paper has been to empirically examine the transparency issue of corporate governance in terms of the interim financial reports (IFRs). The study has analyzed the quality of IFRs supplied by Indian companies through the Web sites of the stock exchanges. For empirical analysis, a sample of 100 firms has been taken. The sample firms represent the most actively traded equity securities on the Indian Stock Market. Based on the analysis performed on sample data, the study has inferred that the quality of Web based IFRs is 'below par' and can be improved further vis-à-vis demands of 'good corporate governance'.

V.K. Vasal is Reader, Department of Financial Studies, University of Delhi – South Campus, New Delhi.

The contemporary global environment is characterized by the large-scale application of information technology (IT) by players of all kinds in assorted segments of the economic system. Indian accountancy profession, capital market regulator(s), and businesses in general have duly recognized the critical importance of IT as a vital tool in dissemination of information to various 'stakeholders'. (OECD, 1999).

Accountability through transparency and disclosures is an important aspect of a good corporate governance model. And, for achieving the objective of accountability through transparency and disclosure, IT, as a tool, has enabled modern businesses, particularly the public-owned companies, to supply information to varied 'stakeholders' with speed, efficiency and (perhaps) a greater degree of reliability. The present paper has examined the transparency and disclosure aspects of the corporate governance for select publicly owned companies in India. Specifically, the paper has analyzed the quality of Web-based IFRs of Indian companies.

Conceptual Background

Ever since their birth as an organised form of business, corporate governance has always been an integral part in the running of joint stock companies. However, the term 'corporate governance' has acquired a fancy in the last one decade or so, particularly since the publication of the Cadbury Report (1992) in the UK. Thenceforth, various bodies all around the world have gone through the rigour of enunciating the principles and formulating a code for the good corporate governance of the publicly owned companies. Some authoritative documents issued since the publication of the Cadbury Committee Report in 1992 are (in alphabetical order) Blue Ribbon Committee Report (the US), King Committee Report (South Africa), Peter Report (Netherlands), and Vienot Report (France). In India, notable contributions have been made by the CII

(1998), Birla Committee (2000), Naresh Chandra Committee (2002), and Narayanamurthy Committee (2003). According to a contemporary school of thought, the present round of literature on corporate governance (including the Sarbanes-Oxley Act of the US) has its genesis in the failures of Enron, Worldcom, Global Crossing and other such mega corporate brands, beginning 2001. These corporate failures, undoubtedly have underlined a need for greater transparency in the accounting practices of the corporate entities (Hazra, 2003).

Corporate governance has always been an integral part in the running of joint stock companies.

As a concept, corporate governance has been defined in a number of ways. According to the International Federation of Accountants (IFAC, 2002), the apex global body of the accountancy profession, corporate governance refers to

> 'the supervision, control and direction of an enterprise's business and affairs by its board of directors and, by delegation, its senior management. It includes the means by which governance responsibilities are fulfilled and accountability is achieved, the processes used to ensure that an enterprise will operate in a safe and sound manner and comply with applicable laws and regulations, and the processes used to gather, evaluate and communicate financial and other information and to monitor and assess an enterprise's performance'.

It is worth noting that IFAC definition has, *inter alia*, laid due emphasis on the processes used to gather, evaluate and communicate financial and other information for good corporate governance.

Amongst the contemporary documents issued on corporate governance, a landmark contribution that has ignited the thought processes of policy makers in various regions and countries, including India, is the set of principles laid down by the OECD (1999). Notably, OECD has divided discussion on the corporate governance in her report into two parts. In the first part, the report presents the principles and recommendations covering five areas, namely, (i) the rights of shareholders; (ii) the equitable treatment of shareholders; (iii) the role of stakeholders; (iv) disclosure and transparency; and (v) the responsibilities of the board. And, the second part of the document contains supplementary discussion in the form of commentary and rationale for the suggested principles. Significantly, a great deal of motivation for conducting this study, and the propositions tested herein, flow directly out of the content of the OECD report. In specific terms, the following discussion and recommendations of the OECD report form the theoretical context for the propositions tested for the publicly traded Indian companies.

As stated above, OECD (1999) has enunciated the 'basic shareholders rights' in the first part of the report. *Inter alia*, these rights include the right to 'obtain relevant information ... on a timely and regular basis' ('The rights of shareholders', Part I of the report). Further, OECD has laid down the principle that the '... corporate governance framework should ensure that timely and accurate disclosure is made on all material matters regarding the corporation, including the financial situation, performance, ownership, and governance of the company' ('Disclosure and transparency', Part I of the report). With regard to importance of disclosure in good corporate governance, OECD has noted that a strong disclosure regime "...is a pivotal feature of market-based monitoring of companies and is central to shareholders' ability to exercise their voting rights" (see 'Disclosure and transparency', Part II of the report). Also, the report has noted that experience in countries with large and active equity markets has shown that '...disclosure can also be a powerful tool for influencing the behaviour of companies and for protecting investors...' ('Disclosure and transparency', Part II of the report). And, a strong disclosure regime can help to attract capital and maintain confidence in the capital markets (OECD, 1999). Thus, in view of the foregoing principles and comments, timely reporting of information is obviously an important element in market-based monitoring of companies. Hence, first of all, timeliness of reporting is identified in this paper as an important research issue that is worth investigating in an Indian context. It may be stated here that reporting in real time is the avowed objective of quite a few corporations around the globe. It is reported that CISCO has institutionalized systems that enable it to close the books of account at the end of every day. Hence, it is capable of disclosing its interim results virtually on a real-time basis.

Second, on channels for dissemination of information, OECD (1999) has opined that they should provide for '... fair, timely and cost efficient access to relevant information by users' ('Disclosure and transparency', Part I of the report). In this regard, OECD has commented that channels for the dissemination of information can be '...as important as the content of the information itself'. Also, the report states that '...while the disclosure of information is often provided for by legislation, filing and access to information can be cum-

bersome and costly'. Of various channels of communications, OECD has noted that '...filing of statutory reports has been greatly enhanced in some countries by electronic filing and data retrieval systems. The Internet and other information technologies also provide the opportunity for improving information dissemination ' ('Disclosure and transparency', Part II of the report). Discussing (in reverse order) the aforesaid key parameters of fairness, timeliness and cost efficiency, the following is argued so far as information reporting through Internet is concerned. Supply of information through the Internet can be at a very fast speed (virtually on a real time basis) and hence very timely. And larger the size and wider the spread of the 'stakeholders', greater is the likely efficiency of the Internet vis-à-vis the traditional paper-based medium. As far as the issue of fairness is concerned, the following recommendation of OECD on equitable treatment (another way of looking at fairness) is worth noting. OECD has recommended that good corporate governance should '... ensure the equitable treatment of all shareholders, including minority and foreign shareholders....' ('The equitable treatment of shareholders', Parts I and II of the report). Given the increasing flows of capital across nations, internet based reporting, as against the traditional paper-based reporting, is arguably more fair, at least, in terms of making information available to all the 'stakeholders' at the same time. Hence, recognizing that Internet as a channel of communication optimizes all the three key requirements of an information dissemination system, the primary research question addressed in this paper is an examination of the quality of Web based interim financial reporting by the publicly traded Indian companies.

Third, OECD has recommended that information should be '...prepared, audited, and disclosed in accordance with high quality standards of accounting, financial and non-financial disclosure, and audit' (see 'Disclosure and transparency', Part I of the report). Also, OECD has recognized that audit by an independent auditor provides '...an external and objective assurance on the way in which financial statements have been prepared and presented'. With respect to these propositions, this paper has examined the extent to which Indian IFRs are currently being subjected to an independent assurance.

Indian Scene

In India, corporate governance assumed centre-stage of discussions in business and economic literature with the issuance of a formal code by CII (1998). Subsequently, Birla Committee (2000), Naresh Chandra Committee (2002), and Narayanmurthy Committee (2003) have also made significant contributions to this subject. In fact, the Securities and Exchange Board of India (SEBI), regulator of Indian capital market, has institutionalized many of the recommendations made by the aforesaid committees by mandating the insertion of a new Clause (Clause 49) in the listing agreement. While many of the requirements enumerated under Clause 49 are mandatory, some of them are voluntary in nature.

In Indian academic circles, although the issue of corporate governance was discussed occasionally at some forums in the late 1990s (Vasal, 1998), the community in general has taken an unprecedented interest in the subject since the publication of the Birla Committee Report (2000). So much so, that many well recognized publications like Productivity (Jan.-March 2003) and Decision (Jan.-June 2003) have brought out special issues on this theme. Significantly, the contemporary academic thought views corporate governance as a game played amongst three players – the corporate managers, the investors and the regulator – with auditors, analysts and regulators being some of the identified mechanisms for 'investors protection' (Hazra, 2003). In this context, a case has been argued in favor of financial reporting and disclosures by highlighting the fact that good corporate governance entails accountability and transparent financial performance (Vasal 1998; Dhameja, 2003; and Bhattacharyya, 2003). Hence, the present study has examined the issue of transparency and accountability in terms of the quality of Web based IFRs in India, apparently for the first time. The issue of the quality of IFR's in the traditional paper-based system has been examined in some earlier studies (see Vasal, 1997).

Good corporate governance entails accountability and transparent financial performance.

In India, notably, preparation and supply of information through the IFR's is governed vide Clause 41 of the listing agreement (an agreement that a company enters with the Stock Exchange(s) where its securities are traded). Accordingly, quality of Web-based IFRs of Indian companies is examined in this paper against the select sub-clauses of Clause 41.

Method

For the purposes of analyzing the quality of Web-based IFRs of Indian companies, a sample of companies representing the most actively traded securities on the Indian capital market is taken. The sample con-

sists of some of the leading Indian companies in terms of their market capitalization. Further, the sample is drawn such that some comparisons between the disclosure practices of meaningfully identifiable groups of companies are facilitated. For making a comparison of the reporting practices between groups of companies, simple statistical tools like classification, tabulation, and descriptive statistics have been used.

Population and Sample – Population for this study consists of all the publicly traded companies in India. In India, currently, there are two premier stock exchanges - the Stock Exchange, Mumbai (popularly known as Bombay Stock Exchange or BSE) and the National Stock Exchange (NSE). BSE is the oldest stock exchange in India with 128 years of history behind it and reportedly has securities of around 7000 companies listed on her. On the other hand, NSE is of a recent vintage and has securities of less-than-a-thousand companies listed on her. In this study, for drawing a sample, a choice has been made in favor of the BSE. Hence, population for this study represents over 7000 companies listed on the BSE.

Since objective of this study is to investigate the quality of Web-based IFRs of publicly traded Indian companies, membership of companies in the foremost security price indexes is used as the primary criterion for selecting the sample companies. It is observed that out of thousands of companies listed on the BSE, 'Index Committee' of the exchange selects the more prominent companies, by applying the pre-determined selection criteria, for constructing a number of securities price indices. Of these indices, BSE 30 index (alternatively termed as 'Sensex') is arguably the one that holds sway on the Indian psyche by default. This is evident from the fact that media (print as well as electronic) often reports the impact of any major economic, political or social event by tracing its impact on the BSE 30 index (Sensex). Notably, first compiled in 1986 (with 1978-79 as base year), Sensex is a composite index of the equity securities of 30 large, liquid, and representative companies. Of other indices compiled by the BSE, BSE-100 (later termed as BSE National Index) is arguably the most important broad-based index. This index (with financial year 1983-84 as the base year) consists of 100 actively traded stocks and is being compiled in

BSE-100 is the most important broad-based index.

Sample Period - For examining the quality of Web-based IFRs, data on the disclosure practices of the sample companies is collected for the quarter ending as on September 30, 2003. For the purposes of inter-period comparisons, comparative data have also been collected for the quarter ending as on September 30, 2002. Owing to periodic revision in the constituents of the two indexes, companies whose securities constitute the BSE Sensex and BSE 100 as on September 30, 2003 form the sample for this study.

Sample data, as per demands of the study, have been collected from the Web-site of the Stock Exchange, Mumbai (www.bseindia.com) over a time-window of two months, October-November 2003.

Findings and Discussion

As stated above, supply of IFRs in the Indian capital market is regulated vide Clause 41 of the listing agreement. Arguably, Clause 41 is one of the more complex Clauses that constitute the listing agreement. Hence, some vital stipulations of Clause 41 are also briefly reviewed along with a discussion on the empirical findings in the following paragraphs.

Since March 2000, Clause 41 requires companies to furnish interim reports at the end of every quarter (a period of 3 months). These quarterly reports (or 'Q-reports') should be prepared as per the prescribed format (see www.bseindia.com for the prescribed pro-forma). Effective June 2003, Clause 41 also requires 'limited review' of the Q-reports by the statutory auditor(s) (heretofore only 'un-audited' Q-reports were required). Under the Clause, companies are obliged to file the 'limited review' report with the stock exchange(s) within a period of two months of the end of a quarter. Additionally, with respect to the second quarter (Q_2), Clause 41 has mandated as follows. Companies should also prepare their half-yearly reports (or 'H_1-reports') (as

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ing interim results for the second quarter (Q_2). Hence, to begin with, it is considered important to identify the interim period/quarters for which the sample companies have furnished IFRs as on September 30, 2003. Empirical findings in this regard are presented in Table 1.

Results presented in Table 1 shows that, as on September 30, 2003, all the BSE-30 companies have supplied only the Q-reports. Although 23 (76.67%) of the BSE-30 companies have communicated results for the second quarter (Q_2), none has opted for the audited H_1-report as a substitute for Q-reports. For BSE-100 companies, on the other hand, it is found that while two companies have furnished audited H_1-reports, the rest 98 companies had furnished Q-reports. As discussed earlier, a company furnishing information for the second quarter in the form of an audited H_1-report within a period of two months is exempted under Clause 41 from filing the un-audited Q-report. For 98 companies furnishing Q-reports, Table-1 shows that 83 (83.00%) companies have filed interim results for the second quarter (Q_2). That is, 83 companies have opted for supplying of Q-reports as against audited H_1-reports. Incidentally, the said 98 companies include all the BSE-30 companies.

Table 1: Quarterly Disclosures by Sample Companies as on Sept.30, 2003

Interim Period / Quarter	Frequency (BSE 30 companies)	Percentage (%)	Frequency (BSE 100 companies)	Percentage (%)
Q_1	2	6.67	3	3.00
Q_2	23	76.67	83	83.00
Q_3	5	16.67	8	8.00
Q_4	–	–	2	2.00
H_1 (Audited)	–	–	2	2.00
Others (un-classified)	–	–	2*	2.00
Total	30	100.00	100	100.00

* For two sample companies, it is found that none of the quarters constituting their accounting periods comes to an end as on September 30, 2003.

Legend : Q_1 - First quarter ending as on September 2003
Q_2 - Second quarter ending as on September 2003
Q_3 - Third quarter ending as on September 2003
Q_4 - Fourth quarter ending as on September 2003
H_1 - First half-year ending as on September 2003

An important quality of accounting data is the reliability of information. It is for this reason that Clause 41 requires companies to subject their Q-reports, at least, to a 'limited review' by independent auditors. Specifically, 'limited review' of Q-reports is in the nature of a 'third-party assurance' on the reliability of the information disclosed through these reports. Though, degree of assurance signaled through 'limited review' is relatively less than that of an 'full-scale independent audit'. An examination of the Q-reports has shown that 3 (10.00%) of the BSE-30 companies have submitted audited Q-reports (hence there is no need for a 'limited review' on Q-reports of these companies). Of the three companies, two are from the 'Computer Software' industry, and one is from the 'Banks and Financial Institutions' industry. Notably, all these companies have supplied their audited Q-reports within a period of one-month. Reporting practices of these three companies are indeed commendable in terms of both the timeliness and the enhanced reliability of publicly disclosed accounting data. For BSE-100 companies, on the other hand, it is found that 6 (6.12%) of the 98 companies (excluding the two companies supplying the audited H_1-reports) have supplied the audited Q-reports (incidentally, these six companies are inclusive of three companies belonging to BSE-30 sample. And, therefore, only three companies (4.41%) have been effectively added out of the remaining 68 BSE-100 companies). Of these six companies, three are from the 'Computer Software' industry, two are from the 'Banks and Financial Institutions' industry' and only one company is from the 'Electrical Equipment' industry. Notably, five of the six companies have supplied their audited Q-reports within a period of one-month. And, only one company ('Electrical Equipment' industry) has supplied its audited Q-report (Q_4) within a (permissible) period exceeding one month. Although relatively a lower percent as against BSE-30 sample, audited Q-reports of 6.12% of BSE-100 companies are commendable in terms of the accounting qualities of timeliness and enhanced reliability. Interestingly, findings on the industry profile of the 'audited Q-reports' have shown that this phenomenon is primarily limited to companies operating in the 'Services sector'.

So far as 'limited review' reports on the Q-reports of 92 (92.00%) of the BSE-100 companies (and 27 (90.00%) of the BSE-30 companies) are concerned, results of the present study are rather disturbing. An examination of the circulars and press releases issued by the BSE until the end of November 30, 2003 has not yielded 'limited review' reports for any of the sample companies. This defect in the reporting practice could be attributed to any one or more of the players involved in the information supply chain, including the stock exchange(s). But, given the fact that a 'limited review' report is in the nature of a 'third-party assurance' on the 'reliability' of information delivered through the Q-reports, the present situation needs to be remedied forthwith for achieving the goal of good corporate governance. It is suggested that stock exchange authorities should take greater interest in delivering this vital piece of information to the users through their Web-site(s) on a timely basis.

Second, for the sample companies, it is found that IFRs at the Web site of BSE provide accounting data for the current quarter only, with no comparatives for the past quarter, year-to-date figures and previous year data. Uniformity with which this finding is obtained for all the sample companies in two years, 2002 and 2003, permits the researcher to infer that the data supplied by the companies is possibly being edited by the stock exchange authorities. This finding is alarming for the reason that the extant Web reporting practice runs against the letter and spirit of Clause 41 i.e., enabling users to compare readily, say, the current performance of a company vis-a-vis its performance in the corresponding period during the immediately preceding year. It could be argued that, with Q-reports given for the past years on the Web site of the BSE, a user could gather data for any number of preceding time periods for the purposes of making comparisons. But, this argument can be countered on the ground that, besides being investor un-friendly, such an action shall entail additional costs (time as well as money) on the user(s) while extracting and preparing the data. Hence, appropriate remedial actions to remedy the present situation are urgently needed. In this context, it is proposed that Indian stock exchanges, like the Tokyo Stock Exchange, should encourage companies to supply their IFRs formatted in, say, extensible Business reporting Language (XBRL). XBRL would make compilation and analysis of data from past several quarters faster, cheaper and more effective (Vasal and Srivastava, 2003).

Third, Clause 41 requires a company to make an announcement to the stock exchange within 15 minutes of the closure of the Board meeting or the meeting of a Sub-Committee of Board of Directors adopting the IFRs (www.bseindia.com). However, Web-based IFRs do not carry any data that shall permit an examination of the corporate behaviour on this aspect. While IT has, on the one hand, enabled low-cost, faster and fair dissemination of information to varied 'stakeholders', it has, on the other hand, created new opportunities for misuse of this tool particularly by unscrupulous managers. For instance, managers may withhold / delay release of price-sensitive information contained in a Q-report beyond the prescribed time limit of 15 minutes. And, given the fact that IT has enabled longer trading hours at the stock exchanges, managers can use this information to serve their interests with dramatic adverse impacts on investors in general. In short, there is an urgent need to strictly monitor such a potentially damaging managerial behaviour. Absence of monitoring of such undesirable managerial behavior, besides being against the requirements of good corporate governance, may potentially cause huge economic harm to the investors. This problem becomes more acute in the light of the fact that IT has now permitted longer trading hours on the stock exchanges. However, a monitoring mechanism to control such an agency problem can be institutionalized at virtually no cost. It is, therefore, recommended here that companies should be required to furnish details, along with their IFRs, on the time at which the Board meeting adopting the interim results comes to an end.

There is an urgent need to strictly monitor potentially damaging managerial behaviour.

Fourth, although Clause 41 has prescribed time limits for preparing and supplying IFRs, IT has provided companies with capabilities to deliver these reports virtually on a real time basis. Therefore, it is considered worthwhile to explore the timeliness aspect of the Web based IFRs. Timeliness has been defined and measured in this study in terms of a 'latency metric', that is number of days taken by a company to supply her IFR since the end of the relevant period. This metric has been used both for inter-firm and inter-period comparisons. Results for the 'latency metric' are presented and discussed only for the BSE-30 companies. For inter-period comparison, the metric has been used on data for quarters ending on September 30 in two calendar years, namely 2002 and 2003.

For the BSE-30 companies, results on the metric have shown that for quarter ending on September 30, both in 2002 and 2003, time taken by the sample companies in releasing their IFRs has ranged between a minimum of 10 days to a maximum of 31 days (one month). Further, for measuring inter-period variation in the reporting behavior, the aforesaid findings of the sample companies on timeliness are investigated further by using a 'latency metric' (discussed above). Results on the 'latency metric' are summarized in Table 2. These results have shown that 13 (43.33%) sample companies are releasing their interim results early (early by days ranging from one to fifteen) in 2003 vis-à-vis 2002. Early release of interim results by these sample companies is interpreted as an encouraging development. However, results have also shown that eight companies (26.67%) have delayed releasing of their IFRs (delayed by days ranging from two to ten) over the sample period. Thus, results presented in the Table have exhibited a mixed picture with respect to inter-period behavior of companies on timeliness of IFRs. Incidentally, these finding, particularly on the delayed release of IFRs, call for further investigation to identify the underlying causes.

Table 2: Timeliness of Interim Reports – 2003 over 2002

Latency (number of days)	Frequency	Percentage (%)
-16 to -9	5	16.67
-8 to -2	5	16.67
-1	3	10.00
0	9	30.00
+1	0	0.00
+2 to + 8	6	20.00
+9 to +16	2	6.67
Total	30	100.00

Summary

The primary objective of the present paper has been to empirically analyze the quality of corporate governance in terms of the quality of Web-based interim financial reports (IFRs). The study has examined the quality of Web-based IFRs supplied by the publicly traded Indian companies particularly in terms of two vital attributes of accounting data, namely timeliness and reliability. Using a sample of 100 firms representing the most actively traded stocks on the Indian Stock Market, the study has inferred that the quality of Web-based IFRs is 'below par' and can be improved further vis-à-vis demands of 'good corporate governance'.

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Unless it produces action, information is overhead.

– Thomas Petzinger Jr.

Feature

Role of Portal in e-Governance: The Indian Perspective

Ram Lal, Abid Haleem & A Rahman Khan

In this paper functionality of e-Government Portals has been discussed such as Single Sign-on, Pushed Information, Alerts, Customized Information, Application Integration, Personalization, Content Management, Collaboration, Multiple Access Devices, Horizontal and Vertical Integration, Channel Information, Technical components and interoperability. Some of the major benefits that citizens are likely to get have also been discussed. With extensive activities being initiated by governments of developed and developing countries to simplify the processes and provide information, single window government portal seems to be the key solution. Examples of some countries that have implemented single window portals have been taken up in this paper.

Ram Lal is with the Computer Services Centre, Indian Institute of Technology, Delhi, Hauz Khas, New Delhi-110016. Abid Haleem is Professor, Mechanical Engineering, and Co-ordinator MBA Programme (Evening), Faculty of Engineering and A Rahman Khan is with the Department of Applied Sciences and Humanities, Faculty of Engineering and Technology, Jamia Millia Islamia, New Delhi-110025.

Comparisons of portals of different countries have been described on the basis of different attributes such as accessibility and skill, effective partnership, interoperability, data standards, and IT training. Comparisons among some major portals of Indian states have also been discussed on different issues such as choice of services, simplicity, convenience, availability and language. A portal should be designed on the basis of the needs of citizens, and should be user friendly involving extensive usage of local languages and sustainable appropriate technology that can deliver maximum satisfaction to the people at large. The government should make arrangements for developing back end infrastructure and a committed work force at proper place to achieve maximum effectiveness in e-governance.

Citizens need government services at one stop. This can be made possible without the citizens going in person to various government offices. So the government has to visualize the needs of the people and put all the services on one platform. This can be achieved through portals or call centres. The extensive use of this technology can change the face of the government and improve its efficiency in a significant way.

In the information technology era, the website provides the electronic face of the government with the dynamic updating of information stored in the government organisations. The portal is the key to the delivery of the services of an e-Government. A portal can best be described as an aggregated point for content functions and features. It provides the ability to chat, discuss, personalize, and aggregate contents. It is a framework that allows existing systems to be tied together and a new technology to be added; which can be shared by all Pulling technology. Information which is needed by citizens should be integrated to provide online services to them and also to remove the citizen's frustration.

A portal is more than a website since it provides a wide range of services such as news, e-mail, search engine, link to other web pages and other services. Information is the currency of the government, and portals facilitate its efficient flow to the constituents. Portals make governments more responsive and citizen-centric by providing centralized users, friendly self-service access to government information for all constituents. Personalization and role-based security procedures ease access to relevant information and deny access to inappropriate information.

e-Government is the integration of Information Technology and government to deliver information to citizens. Its sole purpose is to simplify its process and to provide information to citizens (Ram Lal, Abid Haleem, 2002).

e-Governance

e-governance provides the interaction between the citizen and the government through the electronic medium and decisions are processed electronically. It is necessarily more interactive and goes beyond e-government. Electronic governance involves transformation from a passive information and service provider to active citizen involvement. ("Working Group Report on e-Governance", 2001)

e-Governance Vision

The portal should be made on the vision of "one citizen one face government concept" which will provide easy, personalized, trusted information and services, organized around the needs of citizens. Citizens do not want to know the details of the government organisation but only see that they can easily access information and services at one stop/shop. The main point of the e-government vision is to put a common face on the government by focusing the e-government information and services towards citizens (Brussels, 2001). Computerising the government offices is not e-governance. Only a portal can provide online information and services which are relevant to citizens who can interact with the government by e-mail and other electronic means and also provide the government the right opportunities to listen to citizens' grievances and then provide them a better information service. So it is the right time for the Indian governments to provide information and services through portals enhancing its internal processes and checks to improve its own image through accountability and transparency.

A portal is a gateway to the World Wide Web. The word portal means different things to different people. It is a channel that supports electronic delivery of a number of related services. It provides a common interface with citizens, businesses, staff and other government offices. It is also a website or service that offers a broad structure of resources and services such as e-mail, forums, search engines, and publishing the government information. A portal is an online service that provides a personalized, single point of access to resources that support the end-user in one or more tasks. The resources made available via a portal are typically brought together from more than one source. e-government portal is a web-based interface and the single point of useful, comprehensive, and integrated access for all services and information along with flexible navigation. Portals offer government services on an electronic self service basis, developed around what the citizens want to achieve rather than what the governments want to deliver. They provide greater service to the citizens at a smaller cost. It is a global access point from the perspective of the citizens.

Characteristics of e-Governance Portals

The following are some of the major characteristics of e-government portals:

- It provides a single, unified, browser-based application with independent citizen interface.
- It provides a consolidated view of government services.
- It supports task-specific workflow.

Functionality of e-Governance Portals

Some of the significant functions of e-government portals are discussed in Table 1.

Technical Components

These are the key components that provide a single view of the information coming from multiple sources to the citizens. Some of them are as follows:

Application Server – Application server is an application that uses the Internet for networking and Internet browsers as graphics interface.

Web Server – The web server works in conjunction with the application server to provide the run time environment for citizen requests. Database Server provides services to citizens by processing the query and passing through the application server.

Crawler – A crawler is a compiled programme

Table 1: Functionality of E-Governance Portals

S. No	Functionality	Description
1.	Single sign-on	The ability to see information from multiple systems, in multiple formats, all presented on a single page view.
2.	Alerts	An alert is a notification of an event or change based on one or more conditions involving single or multiple information. This information can be delivered within a portal as well as by other mechanisms such as e-mail or wireless devices.
3.	Pushed information	This is concerned with social, political activities, citizen's government activities notices and e-mailing to a particular group of citizens with a specified interest.
4.	Interaction	A portal can act as an interface to email, group discussion and bulletin board postings on a citizen's subjects of interest.
5.	Customized information	Government is expected to provide citizen centric information.
6.	Application Integration	Citizens can access data from different applications required to complete their work.
7.	Personalization	Each citizen can make settings for each of the portal functions that he uses. A portal provides the framework for citizens to store the settings and tailor the content that they are interested in seeing.
8.	Content management	It is the process of authoring, contributing, reviewing, approving, publishing, delivering, and maintaining content integrated within the portal. Content management refers to text and graphical content that is on view in a web browser.
9.	Document management	It is the process of authoring, contributing, reviewing, approving, publishing, delivering, and maintaining content integrated with the portal.
10.	Collaboration	It will enable a group of citizens to work together to share ideas and finish the work as a team. It also includes electronic interactions among citizens in different physical locations in fixed time and at different time.
11.	Adaptive	The portal should be active to change within the citizens' environment as well as in the web.
12.	Supporting multiple access devices	Users can access the portal when they are away from their computers.
13.	Channel information	Channels can be configured to provide information from various sources on weather, health, education, tax, social services and entertainment.
14.	Horizontal and vertical integration	The information can be searched through different systems within the same functions, and also, the information can be put in the same system within different applications.

that reads indexes and classifies documents at predetermined intervals. A web crawler would target web pages periodically to determine if the content has changed.

Metadata Repository – A metadata repository contains metadata about the content within the portal and about the structure of that content.

Portal – It is a citizen's interface for presenting data and functionality from multiple applications on a single web page.

Filters – A filter restricts the documents that are admitted into a particular folder or which are returned as part of a search.

Taxonomy – Taxonomy is a classification scheme to organize a collection of information. Basically, it takes a group of documents and makes it easy to browse, search.

Standards and Protocol

The following are listed standards and protocols:

- *XML (Extensible Mark-up Language)* XML is a language used to represent almost any type of data. XML is used to communicate the information between programmes and does not have to display information.
- *XSL, XLST (Extensible Style sheet Language and Extensible Style sheet Language Transformation)* - The XSL programme contains rules for transforming the XML data programme into a presentation form that the citizens can understand.
- *DTD (Document Type Definition)* – It is the grammar of XML It describes the grammar rules for documents and provides the facility to verify a document's validity.
- *WSDL (Web Services Description Language)* - Web Services Description Language is an XML based

language for defining web services and describing how to access and connect them. It also specifies the interface to Web services.

- *SOAP (Simple Access Protocol)* – It is an XML based format for specifying methods invocations between computer systems and exchanging information in a decentralized distributed environment.
- *UDDI (Universal Description, Discoveries and Integration).* – It is a specification that provides methods which publish and discover web services.
- *WSUI (Web Services User Interface)* is a specification for standardizing the display of web services to citizens.

Interoperability

Citizens need joined-up government services that are simple to use, effective and organized along their expectations and needs.

Interoperability is required between government-offices, systems and the citizens so that the citizens can have access to government services and information without needing to know which department provides which service. Interoperability is a framework which describes the government's technical specifications and policies for connecting the different Information systems to provide shared information and data across government offices. There are four basic elements of interoperability as described below:

- *Service Delivery:* This element is responsible for providing answers to queries from citizens such as what types of services are to be provided and how the services are to be maintained.
- *Data Sharing and Exchange:* This element is responsible for the recognition of data, recognition methods, formats.
- *Access:* This element provides access to information, authentication and access methods for disabled citizens.
- *Interconnection:* This element covers exchange of information between citizens and an entity (office) of e-government, transmission-mechanisms, protocols for managing the connection.

Differences between a Government Website and a Government Portal

A web portal is more than a website. Some differences between a portal and a website are shown in Table 2, in terms of the merits and limitations thereof.

Portal and its Advantages

A portal provides opportunities to the citizens to interact with the government for information and services online. It gives a sense of ease to citizens and saves money wasted to visit the government offices for information. The portal treats all citizens equally, irrespective of rich and poor, male or female, and provides transparency, which are important factors for the government and citizen's growth. The following are some of the major benefits from a portal:

- Faster - Citizens will be able to find and access information and services faster
- Easier - Citizens can find the information and services they want through the menu, and are easy to use
- No discrimination - Citizens will receive the delivery of information and services without discrimination
- One stop shop - All government transactions can be carried through a single access point
- Pre-filed forms - Citizens will need less time to fill up the forms if the form is pre filled
- Self service - Citizens can access their needs where appropriate
- Staff productivity improvements from computerization
- Lower training costs through 'just in time' training material accessed at the portal. Lower communication costs
- Lower travel costs through collaboration
- Better staff retention and higher satisfaction
- Shared services - there will be a number of shared services available to citizens in a citizen friendly environment via websites
- Reducing workload - a portal will reduce the workload of government offices by delivering the electronic services and information
- Data can be validated by filling the form on line and save office time to remove the mistakes
- Feedback - the portal will provide a channel for citizens to provide feedback to the government and it will enable the government to make the processes better and more efficient.
- Online shared services and information will lead to transparency and efficient governance and also highlight the duplicate and inefficient processes and increase the reliability and trust of the people.

Portal for Citizens

The citizens are not able to access the information and services which the government claims to provide to the citizens. Computerization was made for the internal structure, not for citizen's feasibility, and services. Information and services are accessed through computers in English language only. Hence, the Indian Government has taken steps towards a portal which is citizen- centric, providing information in local languages. There are some things important for citizens such as:

- Design websites to reflect citizen needs, not for the bureaucrats only
- Government sites should not be confusing to citizens
- Websites need to be designed with an intuitive interface and citizen friendly
- Citizens should be allowed to personalize pages
- The portal should support regional /local languages
- The quality and consistency of services and information should be the same and or better than that received through formal written communication
- The portal should be accessed from a variety of channels including PCs, kiosks, mobile phones
- Citizens should be allowed to use the portal anonymously or with unique identification for personalization of portal services
- The portal should be designed to ensure unbiased access
- Privacy of the citizens' information should be protected
- The citizens should not be left hanging. The interactions with the government should confirm receipt, keep transaction history.
- For citizens who cannot access or use the portal because of their disability, illiteracy, or language problem, appropriate arrangement should be made to provide access

Citizen-Oriented Government Services

All the government offices (back office) should be integrated in order to reflect the needs of the front office and the citizens. At the front office, the portal should be designed to cater to citizen's interface and services that will create a one-stop-shop enabling the citizens to access information and services through one point as shown in Fig. 1.

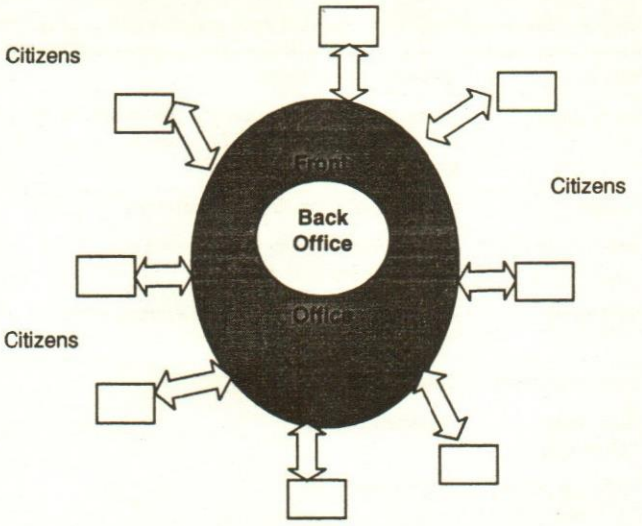

Fig. 1. Citizen Oriented Service Delivery Model

Back end office process reengineering does not only include services and relations with the citizens, but also open up transparent and accountable processes. This includes reengineering of legacy mindsets and attitudes. ICT automated back offices can serve and support very large front offices along with increased quality of back office procedures.

Critical Success Factors for the Portal

The government portal can provide better governance if all sections, including the illiterates of the society can be provided with information and services which are citizens-centric. The performance of government projects depends upon the online information and services uptake available in local languages. The success factors lie with the citizens, content of information, services and technology and also government Critical success factors for the portal which may help in enhancing the services of delivery and enrich the content.

- *Service Online* - The government must commit to put all relevant information and services online
- *Critical mass* - The success of the portal is dependent on the minimum set of services available through the portal including life events
- *Quality of Metadata* - It is a guide map for searching the information and services on the portal
- *Digital Divide* - Complex issues come up at different level of ICT implementation. These issues need to be addressed for successful implementation of the portal. India is a developing country and there is a large gap between the 'haves' and the 'have nots'. Thus, while designing and implementing technology we have to take care of the poor and disabled

Table 2: Differences between a government website and a government portal

Feature	Government Website	Government Portal
Home page	Home page is organized by the structure of the government. Contains a list of government offices	Home page is organized around the needs and interests of citizens Provides task oriented options based on the needs of citizens
Content	Contains mainly static information	Provides information as well as interaction
Look and Feel	Lack of common look and gives one government office feel	Common look across all government offices
Navigation	Navigational systems for users may differ across offices	Offers consistent navigation systems
Citizens support	Weak support	Full citizen support through feedback
Information Technology	Separate from IT	Fully integrated with IT systems
Follow-up action with Hyperlinks	Maybe available	It is a must for supporting citizens
Investment in Technology	Less amount required	Much more investment is required to improve citizens' interaction with government with the help of private sectors
Development efforts	Efforts required	More effort required

citizen's need. Information that arrives in English can be magically transformed to reach disadvantaged groups using any Indian language.

- *Involvement of Top Management* – The success for effective portal design and implementation would no doubt depend upon the will of the top management.
- *Technology* - In the context of India, we have to develop technology strategy. Different technologies are available from which appropriate sustainable technology has to be selected and customised to local usage.
- *Contact with citizens* - The portal's success would depend upon its acceptability to the stakeholders specifically the citizens. Appropriate benchmarking must be established.
- *Provision of up gradation* - Today, half life of technology has become much less. Thus, instead of changing the technology totally there should be provision of upgrading the systems.
- *Operating System, Mail Servers and Content* Should be made in Hindi, local languages, along with English, as the majority of the Indian rural people are poor, non-English speaking and illiterate. Normally Indian rural citizens are traditional and conservative in their approach towards anything foreign.

Global Initiatives Towards Portal Development

There are lots of activities being initiated by e-governments of the developed and the developing countries in order to simplify their processes and help the citizens by providing the information through various media; single window government portal is one of the key activities being followed by these. The following countries have undertaken single window portal.

United Kingdom (www.ukonline.gov.uk)

UK Online is the first government sponsored portal for the British people, developed in partnership with the industry, the voluntary sectors, trade unions and consumer groups. The UK Online portal is a part of e-governance strategy for providing e-services to the citizens. It provides citizen services and consultation channel to citizens and business and is connected to telephones and kiosks.

Canada (www.canada.gc.ca)

The Canada portal is the Internet gateway to the government of Canada for information. It provides access to improved citizen-centred and integrated services, any time, anywhere and in the official language of their choice. It is connected to telephones and kiosks, also. It focuses on the critical elements of a whole-of-government approach and a commitment to innovation driven by citizens' and business needs.

Singapore (www.gov.sg)

E-Citizen Portal is an initiative of the Singapore Government. The portal integrates information and ser-

Table 3: Comparisons of Different Countries' Portals on Different Attributes

Attributes	Portal Countries with Purposes				
	UK	**Australia**	**Hong Kong**	**Sweden**	**Canada**
Accessibility and skill	To bridge the digital divide	To bridge the digital divide	To bridge the digital divide	–Accessibility is an important consideration	
Effective Partnership	e-services can be implemented to reduce risk	Supporter partnership of private and government agencies	Can be implemented at a reduced risk	–	–
Interoperability and data standards	Accountability and transparency will be maintained	More effective services, easy to use and organized around the citizens needs		Accountability and transparency will be maintained	–
IT Training	To view IT as market qualification	Investment in training to keep pace with global ICT environment			Training programmes are a must for targeted audience

vices from various government agencies to help its citizens handle life events. Singapore is a city-state with a single layer of government; the Singapore government stresses the importance of technology innovation and multiple channels of delivery. It has expanded the range of interactive and transactional services available across a variety of government sectors.

United States of America (www.firstgov.gov)

FirstGov is an Internet based Information portal for the United States federal government. FirstGov is intended to be the first resource for the United States citizens to find any government information. There are delivery channels such as counter based and online, telephones, kiosks. It provides feed back channels, online surveys and discussion forums. It also promotes a digital signature initiative.

Australia (www.australia.gov.au)

The Australia portal is a gateway to federal government information and services and has been designed to meet citizens' needs. It provides delivery channels such as counter-based and online, kiosk, and telephone services.

Korea (www.eGov.go.kr)

Korea has adopted a two way approach to implement a government portal:

Government information portal – It provides government information

Government service portal – It provides government services i.e. online transaction between government and citizens as well as the business.

The government service portal, which is branded as G4C (Government for Citizens) with improved search engine functions and directory services.

Benchmarking Government Portal

All over the world, the need as a portal was felt for the delivery of information and services. Various projects have been implemented in various countries to provide information through the front office which is the electronic face of the government. There is key learning lessons which have came up during the course of the implementation of portal projects abroad which are listed in Table 3.

Indian initiatives towards Portal Development

Indian Portal (indiaimage.nic.in) is the gateway to Government of India information. The Indian government is responsible for providing health, education, transport, judiciary, and administrative services. The Indian democratic government is also committed to social empowerment such as education, social class awareness and women empowerment. The Indian portal has to be the one stop shop for all government business in India. This will become the single entry point for all the departments and its sub offices. States of India have started the initiative towards a web portal which is intended to provide online life events cycle and other citizen centred services and government news.

Andhra Pradesh (www.aponline.gov.in)

The Andhra Pradesh government has initiated an Online portal which is the one-stop-shop on the internet with respect to all services to the citizens. It provides

Table 4: Comparing Some Major Portals of Indian States

S.No	Attributes	Indian States				
		Karnataka	**Madhya Pradesh**	**Andhra Pradesh**	**Kerala**	**Rajasthan**
1.	Choice of Services	Information and services provided through web portal	Information and services provided through web portal	Information and services provided through web portal and also STD (Subscriber Trunk Dialling) booths, Kiosks	Only government Portal	Only single access point through Portal
2.	Simplicity	Services organized around citizens needs	Services organized around citizens needs	Services organised around citizens needs	Services organised around citizens needs	Services Integrated and organized as per citizens needs
3.	Convenience	Trying to bridge the digital divide by more citizen participation Available with internet	Where internet facilities are available	Making services available when citizens want	Where internet facilities are available	Where internet facilities are available
4.	Language	English & Kannada	In English	English and Telegu	In English	In English

citizens some government services, government news, AP online help etc. The Andhra Pradesh government is spearheading the concept of converting STD (Subscriber Trunk Dialling) booths into 'Service Delivery Points' (SDP).

Madhya Pradesh (www.mp.nic.in)

The Madhya Pradesh government web portal has been providing citizen services to its people around the clock and it is also connected to all department websites. Gyandoot Project is a unique project in Dhar district, Madhya Pradesh. An intranet network connects the system from district headquarters to cyber cafes (Soochanalayas) across the rural tribal districts of Dhar. A lot of services are being offered to the villagers of Dhar district to help them save time and money.

Kerala (www.kerala.gov.in)

The Kerala government got a new online presence by providing various citizen centred services and connecting the websites of the various government departments. The interactive portal will enable the citizens to send messages to the government and also submit applications online. This portal will act as a gateway to all other websites of the government department.

Karnataka (www.karnataka.com)

The Karnataka government helps its people interact directly through a portal in English and in Kannada and the government has succeeded in the computerization of land records which has helped the farmers of the state to see ownership rights and revenue details. This portal provides information and services as needed by common citizens.

Rajasthan (www.lokmitra.gov.in)

The Rajasthan government has initiated the work by launching the web portal Lokmitra which enables the citizens to access the various integrated services and information of the government departments under a common umbrella.

Comparative Study of Different Indian State Portals

The Internet has showed the path for different governments around the world to simplify their processes and provide information and services required by the citizens. The Indian government and its state governments have initiated work towards providing services through their portals. Some of the Indian states' portals have reached and fulfilled the citizen's expectations which are listed in Table 4.

Concluding observaions

The portal needs to represent a new way of online services and can be effectively utilised for information management. It can also provide a new mechanism to coordinate government initiatives. The portal design should be user friendly involving sustainable appropriate technology that should deliver maximum satisfaction. *E-government should deliver shared services to citizens without requiring them to surf around for the right website with wide range of e-services. E-government should focus on helping the citizens to solve their problems. For this, the E-governance vision has to be*

defined. Portals need to be designed on the basis of functionality requirements. The technical components, standard protocol also have to be specified. The critical success factor for a portal need to be customised... We have learned from some of the experiments undertaken by the governments of developed countries. Thus, its effective implementation will not only change the way the sharing services are delivered but also make the government's processes as well as the government itself. The government needs to arrange feedback infrastructure and a committed work-force to achieve governance flow towards citizens.

We have to work for the delivery of online information with minimum life events services required by all citizens including poor, disabled citizens. The core elements are to develop effective websites and citizen centric portal so that citizens' expectations can be fulfilled. The portal should be developed phase wise keeping in mind citizen centric services and information. Technology standards should be taken up for making the government transparent, effective and efficient in e-governance.

The services provided on the Indian portal also need to be made available in local languages and be accessible through multiple channels including phones digital TVs as well as traditional counters which will be convenient to citizens. Content should be fresh (regularly checked and updated) and relevant. Special attention needs to be given to usability and navigational elements. A careful consideration of security issues, information protection for promotion of the portal to generate a critical mass of users is a critical issue.

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"Working Group Report on E-governance", November,2001, www.gipi.org.in/egov/ rpt_wrkng_% 20grp.pdf Table 1: Functionality of e-Governance Portals

An invasion of an army can be resisted, but not an invasion of ideas.

– Victor Hugo

Feature

Determinants of SME Success: Formulating a Business Strategy

G.D. Sardana

SMEs are mostly family owned organisations operated by entrepreneurs who are not exposed to management education. Globalisation and the liberal trade policies permitting unrestricted imports has ushered in a customer driven market. The subsidies and state protection to the small industry has been withdrawn. The industry has to defend and save its existence. However, explosion in knowledge based industry and the service sector has created, simultaneously, new opportunities. Many of these challenges are best suited for the strengths of the small scale sector. These strengths lie in low costs, high responsiveness to customer needs, flexibility, high motivation of employees. Lack of finance and deficient controls on receivables are major weaknesses. The paper explores these issues and makes a strong plea for formulating a business plan to exploit the strengths and transform the weaknesses to advantages.

G.D. Sardana is Professor, General Management, Amity Business School, Noida.

SMEs constitute an important segment of economic activity. Most people, be it employees in various functional areas of a business undertaking or persons looking for employment, contemplate starting their own business at some time or the other. The idea is irresistible as it provides a fillip to the urge to become self-reliant and master of your own show. Running a small business is an exciting and challenging experience. Success brings in returns and a sense of immense satisfaction. Thus, it is found that the extent of SMEs both in developed as well as developing economies is increasing day by day. There are over 300 million SME units in India as per one estimate. Birt and Sleeman (1994) report about 859,000 small enterprises in Australia in 1993, which represent about 95% of all categories of business undertakings. The SMEs are distributed in all the three sectors. In the primary sector these are visible as engaged in production and related activities of agriculture and livestock. In the secondary sector SMEs have accepted challenges to exist as small factories and small engineering workshops. The tertiary sector comprising of the service businesses is the main domain for the small sector. These dominate construction, retail trade, property dealings, healthcare, hospitality, consultations, IT-oriented sectors and pharmaceuticals. FMCGs and the automobile industry have traditionally been dependent on SMEs where the latter constitute as first tier suppliers. The competition has increased. There is an increasing threat from the external environment. Under the regime of free trade and globalisation, the state has withdrawn the protection it provided to small-scale business. Large organisations can now take up products and services which till recently were reserved for the small-scale sector. Large multinationals are now free to export the goods hitherto reserved for the small-scale sector. Proliferation of malls in metros and larger towns is threatening the age old retail-shop trade operated by small businessmen. An SME has to bring in higher efficiency or intelligent working for success. It requires exploiting its own strengths and avoiding pitfalls. A proper understanding of the

small business operation and needed management controls can make the business not only survive but also grow. An SME has its own compulsions, problems unique to it and therefore it requires a unique business strategy that is different from that pursued in case of large units. This paper examines the characteristics of an SME and examines how these differ from a large enterprise. The study details what determinants lead to the success and what constitutes a business strategy for a small business. The paper emphasises the need for formulating a business strategy for the survival and longevity of the enterprise.

What constitutes an SME?

There is no standard definition of an SME. Indian laws have linked it with investment. Many nations have prescribed turnover limits to differentiate the same from large units. Criteria of employment have been also used to define the same. These approaches take into account the socio-economic and political compulsions and are adopted basically to transfer economic benefits such as tax concessions, preferential purchases of outputs by the state agencies, subsidies, easy sanction of loans on special lower interest rates, higher credits on purchases from the state undertakings etc. Classification under these criteria, however, has a limited scope to enable a person comprehend the issues faced by an SME in its business operations. A more rational classification has been provided by The Small Business Act (1953) of the US which defines small business as "one which is independently owned and operated and is not dominant in its field of operations".The Committee for Economic Development (US) recommends to adopt any of the following two criteria to classify a business as small:

- Independent management, usually owner managed
- Capital as supplied by the owner
- Local area of operation
- Relatively small size within the industry

Birt and Sleeman (1994) also take a similar perception and propose an all-comprehensive definition that a small business has the following characteristics:

- The business is owned by one, two or several persons
- The owners also manage the business
- The owners frequently work alongside their employees
- The owner-manager makes all the key decisions
- The business is independently owned and operated
- The business has limited money capital
- The business has a small market share
- The business employs less than a hundred people in manufacturing activities and less than twenty people in all other activities

Megginson et al. (2000) also advise similarly that a small business is characterised by:

- Management is independent, since the manager usually owns the business
- Capital is supplied and ownership is held by an individual or a few individuals
- The area of operations is primarily local, although the market isn?t necessarily local
- The business is small in comparison with the larger competitors in its industry. Indirectly these features can be used to adjudge if an enterprise is large or constitutes an SME. In the context of this paper we shall be guided by this approach.

Pattern of failures

In spite of an increasing numbers of SMEs every year, unfortunately it is a fact that there is a large number of failures of these ventures. Megginson et al. (2000) quote an early Minota Corporation survey concerning US small business that: over 48 percent failed on account of lack of capital; 23 percent for lack of business knowledge; 19 percent for reasons of poor management; 15 percent because of inadequate planning; 15 percent on account of inexperience and 28 percent for a cluster of small reasons. In another detailed study devoted to small business in Australia, Birt and Sleeman (1994) point out reasons of failures as: 32 percent on account of financial mismanagement; 15 percent for management incompetence; 12 percent for poor record keeping; 11 percent for sales and marketing problems and the balance 30 percent for other miscellaneous reasons. It is interesting to note that in both the studies, internal reasons for the failure top the tally at a score of over 60 percent. Birt and Sleeman (1994) provide another interesting data related to the average age of the small business. Almost 90 percent of the industry fail in the first three years. Of the same around 50 percent does not survive beyond the first year of the operation for lack of cash. This explains the reluctance of the banks and the financial institutions to extend finance to the sector. It is only 5 percent of the population, which

survives beyond 5 years. The data on mortality is useful to analyse the causes of failure and to the formulation of a business strategy for survival.

SME Environment

An SME operates in a business environment with distinct characteristics. It differs from a large unit in many ways. An SME enjoys its strengths which are not common with large units. If these are understood properly and appreciated, this can lead to an appropriate formulation of a business strategy and a key to success. Conversely, absence of a strategy or its wrong formulation can only generate a traumatic experience. It is true that an SME has limitations in several areas of business. This makes it all the more imperative that an SME recognises its core competencies and the source of capabilities in a proper perspective so that these are exploited fully.

Strengths

Strengths of an SME essentially originate from the personal attributes of the promoter. His degree of motivation, ambition, value system, creates a culture in the organisation. The employees adopt him as the role model. The entire structure of the organisation gravitates with him as the axis. He determines the style and the shape of the operations. The strengths so created are visible in the following areas.

Strengths of an SME essentially originate from the personal attributes of the promoter.

Decision making and controls: The owner is the manager. He alone has the responsibility to formulate the strategies at the corporate, business and operational levels. The resources are within his control as he determines the deployment. The decision making and the management controls are faster because of two reasons. Firstly, absence of hierarchy allows the feed back on results to reach the owner faster. There is an intimate link between the planning, work processes and the outcome. Faster feedback enables the owner to adopt alternate strategies or help changing the priorities. Secondly, the owner himself is involved in the decision making. This enables him to take quick decisions within the constraints of the resources known to him. Employees who have to be rewarded or motivated do not have to wait long. As the decisions are taken at the highest level, there are no controversies on the right or wrong of the decisions.

Operational efficiency: Smallness of size enables the owner-manager to pursue the targets vigorously. Normally, the owner is personally involved in the operations through his physical presence and through his inputs of expertise and knowledge. Time, work hours and procedures do not become constraints. The owner-manager leads the team through his own example of hard work, long hours on the job and a single minded zeal to accomplish the task. The employees are left with no alternative except to put in hard work and perform efficiently. There is a strong focus on performance. Productivity is high. An SME becomes a focussed factory. Even lack of resources does not deter the operations and the employees tend to innovate. There is less of procedural delays, high degree of empowerment, absence of bureaucracy. These factors help increase efficiency.

Response to change: Today's economic environment is fluid, dynamic, ever changing and complex. There is a faster change, as Lowson (2000) says, in social values, consumer tastes and customer service expectations. A consumer expects faster reaction to his demands on product attributes, features and performance capabilities. Absence of hierarchy and bureaucratic controls enables an SME to take cognisance of market changes faster. At operational levels it is easier to make changes in the technological parameters such as tool set-ups, job changes and transfer of skills in a small business as compared to a large industry set up where large batch sizes are being run on automatic machines. Small size also compels employees to develop multiple skills of a generalised nature. This again is instrumental in responding to new requirements faster as the skills are easily available.

Relationship management: The owner-manager is in a position to develop a strong relationship with employees. Firstly, he is almost always available at the work place. The employees therefore have an easy access to him leaving hardly any issues or grievance unresolved. Secondly, the small population of employees in the organisation brings them closer to the owner. They become a part of the extended family represented by the owner as head. The owner-manager goes out his way to participate in the family functions of the employees. At the time of distress the owner-manager extends all financial help often without an employee asking for the same. The rules and the regulations of discipline such as sanction of loans, leave, late coming are diluted for the convenience of the employees. This creates an immense satisfaction and sense of loyalty towards the organisation. In the event of crisis the extended family considers the problems faced by the company as its own.

Similarly, a strong relationship comes to exist with customers. The key customers become the source of information to the company for any new products or emerging new preferences of the customers. A strong relationship ties down the customers with the company even when the product or service performance is down. The goodwill generated by the relationship is instrumental in building a strong service image in the market. This is more effective than the costlier product promotions. Much of the present day philosophy of CRM has origins in relationship principles developed by the small industry.

The key customers become the source of information to the company for any new products.

A strong relationship is also visible with suppliers and other stakeholders. With suppliers it helps in obtaining fast changes in technology or introduction/deletion of features if so demanded by customer preferences. Urgencies of supplies can be better conveyed and actions expected only in the event of close understanding with the suppliers. Relationship can be helpful to some extent in tiding over the demand far overdue payments as the suppliers come to understand the difficult times the owner-manager is in.

Low Costs: The principal reason for the low costs is the missing overheads. He cannot afford to hire specialists. Even if he hires he cannot justify their existence in the firm because of lack of sufficient job responsibilities. Similarly, in the domain of financial investments, a small industry requires a general purpose plant as against the requirements of automation needed by a large scale one for reasons of economies of scale, This again brings down the cost per unit of production.

Weaknesses

An SME is weighed down by a host of weaknesses. These are spread out in several areas. The weaknesses impact the performance, impede growth and can sometimes endanger the very survival unless timely interventions are not made. Not all the weaknesses can be entirely eliminated. The key to what constitute weaknesses lies in understanding the areas of failures. These can be classified as under.

Lack of Financial controls: Shortage of funds happens to be the single largest reason of failure for an SME. An organisation survives as long as it can deliver the perceived value to customers and expected return to its promoters. It, therefore, has to live within the financial controls by managing the financial resources of the company and ensuring that the fund constraints are not breached during the operations.

There are three distinct stages when the shortage of funds can occur. At the first stage when an enterprise is in its infancy (usually the first year of start up), the unit faces shortage of funds essentially because of inadequate assessment of the needs of capital to set up facilities, procure supplies and transform the same to marketable products. The situation can become complex if the receivables get delayed, a situation seldom thought of before by the owner. The unit gets stuck. There is a pressure for payments from the suppliers of plant and machinery and materials. The newly hired employees are ever willing to leave the ship which is not even fully floated. The weakness of the system is in the improper and inadequate assessment of its financial needs. Lack of knowledge on project planning or professional experience on the part of the owner-manager are the main reasons.

The weakness of the system is in the improper and inadequate assessment of its financial needs.

The second stage of operations is when the unit has apparently stabilised its operations and balances its income with expenses. For a unit aiming at profits the former has to be higher than the latter. The failure occurs when there is disturbance in the system. Changed pattern in demand may result in overstocking of materials and goods produced, or failure on the part of customers to pay on time or failure on the part of the organisation to exercise controls to realise the outstanding payments. An SME is obliged to extend credit to its customers This is done, as Andi Axman (2003) explains, to encourage higher sales, to increase goodwill and to make customers less sensitive to price and more focused to receive services from the company. Provision of credit is one of the most valuable tools to promote sales in the hands of an SME in absence of alternatives such as brand, promotional activities, technological superiority, consistency of product quality as enjoyed by large units. Relaxation of collection of receivables or extension of credit or 'dumping' of saleable goods to a distributor by waiving the normal terms of credit result in shortage of liquid funds, disturbing the careful balance between income and expense. Lack of financial controls is the principal reason for this state of affairs. Although in the long run, over the life of the

company the total cash flow may be favourable but in the short run there are no funds to meet the commitments. A crises gets created.

Third stage comes when the owner-manager is satisfied with the progress of his unit and aware of the potentials of the market. This calls for procurement of new facilities and new capital assets. He also has the conviction that a higher volume will lead to lowered costs of production. In anticipation he even lowers the prices of his products. In this process the growth in profitable activity outstrips the cash necessary to resource it. David Otley (2002) explains that the major difference between profit and cash flow is the time period between payments made for capital assets which will generate income in the future and the actual receipt of that income which is needed as working capital. If the cash flow is not as per the plans both in time and quantity, the liabilities cannot be met, even though the firm may show profits in the long run. At the third stage this amounts to a weak focus on the assets and the provision of finance for their purchase. In accounting terms this refers to a weak focus on the balance sheet rather than on profit and loss account for a cash flow statement. For unfortunate reasons if the firm is not in a position to use the new investment to its full capacity neither shall it be able to raise resources to meet the commitments nor will it be able to lower its cost of production.

In overall terms the weakness refers to financial management on acquisition of financial resources to meet needs of assets and the working capital and the interaction between these two entities.

Inadequacy in business management: An SME is highly constrained to hire professionals or highly experienced executives. It cannot afford to pay. If hired these high salaried managers remain unoccupied because of unavailability of full time occupation and therefore they add up the costs. The personal attributes and the mindset of the owner-manager, therefore, determine the style, the process and the structure of the management. The owner-manager is virtually an all-in-one-manager controlling various functions. He plans, directs and controls all the business processes of design, production, HRM, marketing, procurement, distribution etc. He becomes the ultimate authority on various skills. There is hardly any delegation of authority or accountability. The causes for failures or defaults cannot be traced as every action leading to success or failure has origins in strategy formulated by the owner-manager. For reasons of protection of the personal image, the owner-manager would not be interested in an in-depth analysis. The practice of management, thus, becomes the result of bounded expertise and knowledge of the owner-manager. For an organisation, this creates inadequacies to achieve effectiveness, efficiency and performance. In the long run a fixed mindset gets created in the organisation. Even if the organisation hires a professional for some areas of operations, there is a limited possibility of his getting a reasonable delegation of powers to follow an independent approach in business transactions. Perforce he is expected to follow practices set by the owner.

Besides, the owner-manager is ever conscious to exercise close supervision. He carries an apprehension of losing his hard earned capital through the "casual" outside professionals, howsoever qualified they might be. His mindset does not permit him to accept that a professionally qualified executive could deliver results in a planned manner more proficiently. It is, therefore, not uncommon to see that many owner-managers will position young siblings/relations over experienced executives for overseeing the business operations, especially in non engineering functions. The mindset of the owner is a major roadblock in the progress of an SME to become a large sector corporation.

The owner-manager is always under the perceived threat of being watched and his operations under surveillance. Besides, the entire management controls are in his hands. SME units tend to operate under a cloud of secrecy. Employees know the business operations only in parts. A composite whole is never known. There is a lack of transparency in the system. An employee, therefore, is usually not aware of the status of performance of his company and is not in a position to contribute if the matters go wrong.

The large powerful suppliers have the advantage of stopping the supplies or not matching the demands of their small customers.

Power Imbalance: For business reasons an SME has to deal with both large and small suppliers. Some of the supplies such as proprietary items, components of mass production, trademark items, come from large and powerful suppliers. Such types of suppliers tend to view an SME with suspicion. The powerful suppliers are neither sure of continued orders nor long term relationship or the ability of the small business to adhere to the terms of the payment. For reasons of largeness of their size, it is immaterial for them to lose an order from an SME. The large powerful suppliers have the advantage

of stopping the supplies or not matching the demands of their small customers in preference to the larger consumers. A similar situation exists in case of large powerful customers such as distributors holding excusive rights for large territories. Such customers would attach first importance of making payments or placing of repeat orders to established large manufacturers supplying branded goods in preference to an SME. This power imbalance can play havoc in business dealings. In critical situations it can result in stoppage of vital supplies with no alternates developed or refusal to clear receivables by major customers when funds are needed most. A small business has no bargaining power with the large powerful suppliers and is always at the receiving end in matters of revision of prices, disputes on quality and failures to meet supply schedules. Simultaneously, an SME has to avoid switching suppliers, as the costs involved are high. It has to be appreciated that an SME cannot develop and sustain a long-term relationship with powerful suppliers and customers.

Absence of specialisation: Lack of resources and inability to hire professionals encourages generalisation in an SME. The employees at the lower levels become adept at multiple skills. They can be referred to as master craftsmen. They can be rotated as and when needed on different jobs. Similarly, at the supervisor level the personnel become generalists to carry out various functions. In the process the employees in general do not possess the strengths of specialisation. This restricts the enterprise in carrying out serious types of innovations and development work. The larger units become the role models to guide the SME unit to alter technology and to bring in new features in products or develop new processes. Absence of specialisation and restriction in size also prevents an impact on the external business environment. Even though the unit might have worked out a successful innovation, the market is unlikely to accept the same easily and would rather seek confirmation of the same over time through development by larger units. The resources so spent by the SME on development go 'waste'.

Absence of business strategy: An average SME is not found developing a business strategy. Naively it considers that such an approach concerns large units. As a result it is not in a position to develop a consistent policy related to business. There is absence of any focussed approach. Strategies go on changing from customer to customer. Soon a label of 'unreliable' gets affixed to the organisation. The real reason for this state of affairs lies in the fact that the owner-manager is not equipped to carry out this type of exercise for want of knowledge. It is, therefore, often observed that an SME has no clear laid out approaches to seek success and growth even though it has strengths and opportunities.

In a similar context an SME can also be seen to lack in performance orientation. There is no visible motivation or a recognition system to award those who perform. An SME is handicapped, Sardana (2001) points out, by the absence of organisational strength and want of qualified professional executives. Employees who cater to whims and fancies easily influence the owner-manager. A conviction develops that employees can be easily replaced because of high unemployment. Such an approach shuts down any opportunity for an employee to come forward and participate in strategy formulation. Commitment, sincerity and innovativeness become casualties.

An SME can also be seen to lack in performance orientation.

Lack of technological superiority: Shortage of funds and smallness of size in low volumes do not create compulsions to install the latest technology. Technology in the form of automation or a plant with advanced engineering, tooling, new processes cost money. These factors also require support services, test laboratories, control instrumentation, qualified engineers and technicians. The low volume production requirements do not justify the same and will only result in higher per unit cost of production. In another dimension of technology, the enterprise cannot afford to install facilities for innovations and product or process development. It has to depend on outsourcing the same. The overall impact is that an SME lacks technological superiority in most aspects of functioning.

Lack of quality: In terminology of design and manufacturing quality is compliance of specifications, design attributes and dimensions so as to obtain consistency, reliability and durability of the product. Quality is thus a function of technology and an attitude. All the aspects of quality including product design quality, process quality, performance quality is dependent on technological focus, which is lacking in the small business. It is also observed that SMEs are not serious to inculcate quality culture in the organisation. Quality awareness programmes are a rare event so that the employees do not understand the importance of quality. SMEs are not known to create quality management systems to plan, promote and monitor quality. This results in providing poor service to customers. These aspects are often justified on grounds that small business gets only undiscerning customers and price is the only criteria of decision-making.

Lack of clustering: Clustering refers to concentration of units of similar industry at one geographical loca-

tion. This factor has several advantages. A labour pool of like skills gets created. This labour pool is readily available to the units saving considerable expense on training. A high rate of mobility of labour occurs which is advantageous to the industry as it brings new ideas, information on product development, induction of new technologies and expertise. The skills practised over the years also increase levels of productivity and quality of workmanship. The wage levels also get stabilised. There are several instances of this type of clustering which has brought major advantage to the specific industry. Coimbatore and Ahmedabad for water lifting pumps; Ludhiana for bicycle and sewing machines and Rajkot for brass hardware are well established cluster names. These centres lead in bringing out new models of the products at regular intervals. Their product prices are competitive and the products enjoy better quality. The new models are seldom from one firm; a number of firms are seen to introduce similar models almost simultaneously. Clustering also attracts customers as it helps them to choose and negotiate from alternatives. These centres become the right place for outsourcing as the customer develops confidence on availability of capacity and capability of supplies as and when the demand has to be increased. Besides, clustering is helpful to generate infrastructure specific to the industry. The infrastructure includes packaging facilities, transportation, telecommunications, power supply and processes unique to the industry. On the other hand it creates a mass of supporting services of experts who understand the needs of the industry. This may include test laboratories, consultancy firms, accountants and specialists. The suppliers also get attracted to the cumulative demand to set up their facilities for manufacturing and distribution. The clustering leads to increased knowledge flow, increased social interaction with the competitors and the suppliers so that an SME gets access to the latest developments in products and technologies.However, most of the SMEs do not enjoy the benefits of clustering. The owner-manager has the tendency of staying close to his family. He has a limited interest to move the facilities to place of clusters as this will involve his shifting as well to the place. Lack of clustering brings delays in start-up of operations, in innovations and new developments and in bringing quality to an acceptable level. Often the costs of the product in absence of clustering are higher. As a matter of fact an SME remains unaware of the new products and technologies introduced by its competitors for quite some time because of the absence of clustering. The initial delay proves a costly exercise.

The clustering leads to increased knowledge flow, increased social interaction with the competitors and the suppliers.

Opportunities: Change in the business environment has opened up new opportunities for small business. Consumer is today conscious of quality. Never before had he the choice of such a wide range of products and services. This is one dimension where an SME can look forward to search for customers who are not satisfied with present supplies. In another dimension the free trade and the removal of tariff restrictions have opened up new geographical market areas in unexplored territories. Thirdly, a wide range of new businesses have come up which can be best performed only with the attributes possessed by the small business. Some of the major opportunities are discussed in the following sections.

Exploding market: Markets for the products and services are created normally by larger units through their innovations. The efforts get supplemented through their aggressive promotion and existing brand image. Both at global and domestic levels the product demand exists and stands to increase with increase of prosperity. An SME does not have to worry to create a demand. An SME can take advantage of the demand created by proper alignment of its business strategy with its strength of producing goods at lower prices and providing better customer service. Quality improvement alone can open large business opportunities. In real terms it is not going to cost a fortune to generate quality consciousness amongst employees. The owner-manager is to recognise that quality of the product and quality of service constitute success in a consumer driven market. For an SME these are vital pre-conditions for survival. With levels of acceptable quality, the inherent strengths of low costs and customer service there is no reason why it should not be able to achieve its share which in any case is only an infinitesimal share of the total market. An SME can carve a niche market at remunerative prices and provide a challenge to the larger units.

Customised products/services: A customer today has a large choice of product models. Many manufacturers tend to provide add on features to attract customers. Discerning customers look forward to products which carry a stamp of exclusiveness. There is also a class of customers who demand specific features to be added to either meet their technical requirements or to get a feel of uniqueness. This category of customers is willing to pay extra. There shall always be an unexecuted demand of this dimension. This demand cannot be met by a large unit, which tools up its production to obtain advantages of large volumes and low costs. The business strategy for a large unit is focused on these

parameters. However, it is only the small business equipped with systems of small batch sizes and flexibility in its operations for a fast change over to new job settings or changed volumes that can easily adjust to customer expectations. The master craftsmanship or the generalisation so prevalent in the SME organisation is a fit environment for this type of demand. Interestingly this brings in better returns as contrasted to mass-produced products. An SME has to locate unsatisfied customers for this business.

Alliances with global units: Free trade and rationalisation of tariffs have opened up markets to business. More and more enterprises are becoming global units. These corporations identify markets and formulate plans to supply goods at same quality in markets situated in different geographical locations. It is not possible to supply and distribute goods from one central facility. The costs of storage, distribution and the time likely to be taken to meet the demand do not justify this approach. It is imperative that global units put up several manufacturing facilities at spread out locations all over the world to meet the market. This can be justified only with volume demand. Alternately, the market has to get either the complete goods or parts thereof manufactured through small businesses under close supervision and technical collaboration. Global corporations engaged in white goods have already adopted these practices successfully. It is also a standard practice for FMCGs and the automobile manufacturers to develop such suppliers for supply of parts, components and sub-assemblies. More of such opportunities are likely to get generated as the trend for global units increase.

Outsourcing: Imperatives of global business environment have also created the need for competitiveness on cost of products and services. Small business has the inbuilt advantage of low overheads. Besides, there are large differentials on wages in different areas for various reasons, which can be exploited by locally positioned SMEs. The need for outsourcing is not limited to obtain low costs. It also concerns getting advantages of core competencies of the enterprise. These competencies can be special skills, customised production of small batches, craftsmanship, design and development, research in specialised areas or unique processing facilities. These are the core competencies inherent in the small business. Besides, there are advantages of knowledge of local market, preferences of the consumers, social and economic profile of the potential customers being better known to the entrepreneur based in that geographical segment. A large manufacturer would be interested to even outsource his marketing operations to such SMEs. Outsourcing has become an important component of business strategy. Computer software IT, have in recent times emerged as major business areas of outsourcing.

Small business has the inbuilt advantage of low overheads.

Emergence of the service sector: Service sector has already displaced the manufacturing sector to occupy first position in generation of GDP in the developed economy as well as in most of the developing economy. The service sector has a high preponderance of the knowledge and a high customer service orientation. Both of these attributes are best suited for an SME. With its flat structure and less of bureaucracy it is able to develop a one to one relationship with customers and provide services aiming at high satisfaction to customers. Healthcare, hospitality, Consultancy, IT-enabled services, Entertainment, Education have opened immense opportunities for start of SMEs by professionally qualified entrepreneurs.

Changing business environment: It has been discussed in previous sections that a small business cannot rely upon the long-term relationship with its large suppliers because of the power imbalance. Viewed differently this aspect also brings advantage to the enterprise as the unit is no longer bound or committed to procure the supplies to older designs and the old prices as would be the case with large manufacturers. The business environment is quite dynamic and brings in changes because of social and economic changes taking place all over the world. These developments are accompanied with, as Lowson (2002) points out, variations and changes in transformation activities. For an SME it is generally easy to manage change without any major reorganisation of the operational structure. Its strengths of flexibility, multiple skills, responsiveness, strong relationship, ensure that a changed business environment is used to its advantage. The smallness of the size always keeps it vigilant to changes taking place in the environment. Besides, the process of planning and management controls are closely linked for reasons of both being supervised by the owner-manager. Thus, there is a faster reaction to any changes in the environment. It can be said that an SME thrives in the changing business environment.

Threats

With state protections being withdrawn SMEs hardly enjoy any distinction from larger units except in size of operations. It can be said that the small business suffers

With state protections being withdrawn SMEs hardly enjoy any distinction from larger units.

from the absence of all those advantages, which are enjoyed by large units on account of size of operation. The non-existence of these advantages can lead to threats to both success and eventually, survival of the enterprise. The other threats originate from the changing business environment. Some of the major threats are discussed as under.

Globalisation: Revolution in IT and globalisation has created an awareness of branded products and their specifications. A consumer knows what is popular and what is consumed most outside the boundaries of his micro environment. This has resulted in this planet being converted to a large family. The social habits, likes and dislikes are steadily getting diluted and a common culture is getting evolved in favour of the large global corporations protected by patent laws under the regime of WTO. In the final analysis it is the small business which will find erosion of its business if the same is in direct competition with large enterprises. Lack of resources will not permit it to promote its product even in the close environment in which it operates.

Low Costs: Very large enterprises especially in areas of FMCGs operate on mass production technology. This involves application of automatic machines and continuous processes. There is an inherent provision to maintain consistency of the product in physical dimensions and in performance. There are in-built controls to monitor processes. The processes are not subject to the subjectivity of manual controls. This is also responsible for low rejections at the time of processing. Besides processing, a large unit has the system of breaking down tasks into components and assign the same to its specialists to work out value analysis and search for processing solutions so as to minimise the cost of production. The overall impact is a low price. It is difficult to convince a customer to ignore this parameter especially if this is supplemented by strengths of brand image and quality.

Better Quality: Quality has origins in product design, processing and the internal culture of the organisation. A large organisation normally has its own R&D facilities to develop and introduce innovations. It is, therefore, in a position to vouch for its designs. Processing on automatic machines introduces components of quality like reliability, consistency and long product life. A large organisation also takes pains to go through the exercise of extensive training of its employees to create a culture of quality consciousness. Regular meetings are held to take stock of failures. On the other hand, a small unit has to base quality on the type of equipment it possesses. In most of the cases either the facilities are old to generate comparable quality or there is only a lukewarm internal interest to insist on quality. The field rejections or the problems faced by the customers in operations are not subject to analysis as there is no infrastructure to carry out the same.

A large organisation also takes pains to go through the exercise of extensive training of its employees to create a culture of quality consciousness.

It is not necessary that a large organisation will always have better quality products. It is also observed that an organisation with best quality product does not always enjoy the largest share of the market. Very often it is the brand image and the hype associated with it which creates a general perception of the product also being of the best quality. The general consumer goes along with the perception that the product quality has to be excellent as the same comes with a well known brand. In brief, the large organisations have the advantage of both good quality and perceived good quality. This poses a threat to small business.

New Products: Introduction of new products and innovations is a regular activity in a large unit. The R&D efforts provide a continuous platform to the company to evaluate the performance of its existing products and eliminate unsatisfactory models. R&D activities also provide a competitive edge to the large unit. By the time small units copy the design the large unit is ready with the next model. Besides, any introduction of a new model is essentially with a view to obtain advantages of better performance and reduction in costs, The products from the large units are, therefore considered as incorporating latest designs. There is a behavioural aspect as well, which makes the large unit as preferred supplier by the customer. Introduction of new models and innovations convinces the consumer that he is in the capable hands of a manufacturer who is fully equipped to design, to introduce innovations and improve the performance of products.

Technology Obsolescence: There is a rapid rise in the development of new technology. Most of the changes are related to new designs which call for use of new materials, application of processes involving precision,

high inbuilt quality, reduction in size without sacrifice of performance and safety in customer usage. This is more evident in IT enabled services and service sector related to healthcare. Most often new processing plant and machinery is involved. The older design of the product and the related plant in most of the cases becomes redundant. Introduction of new technology is an expensive exercise. It involves procurement and installation of new facilities, absorption of the technology, creation of infrastructure, training of employees before a desired level of productivity can be reached. Besides it calls for discarding the old technology without any returns. The small business is faced with continuous threat on this account.

Turbulent Environment: Most business resides in a turbulent, dynamic and complex environment, dictated by customer preferences and his rising expectations. There is also an explosion in technology. Simultaneously, there is an increasing awareness about the environment and the avoidance of indiscriminate use of resources. The industrial and the service sector not only bring out new products but also create new needs and demands. There is no certainty on this ground. All the efforts may result in zero outcomes. Large units can withstand the impact of failure in this respect. However, the small units are handicapped. They have only a limited role to impact the environment. Frequent changes in supplier and customer configuration is another area of concern. These factors make SMEs highly vulnerable to the external environment.

Formulation of a Business Strategy

Strategy concerns taking decisions on various alternatives to obtain an organisation?s sense of purpose. It proposes future directions for planning, procuring and deployment of resources concerning products, markets, technology, manpower and finance. Lowson (2002) defines it as ?the pattern of major objectives, goals and purposes and the fundamentals, plans, policies and philosophies for achieving those goals, that are declared in such a way as to define what business the firm is engaged in, or wishes to be engaged in, and the kind of organisation it is or would like to be?. Strategy formulation, implementation and control, therefore, have come to constitute a blue print for transformation of corporate mission into reality. Strategy has been viewed from three vantage points. Corporate strategy refers to the 'WHATS' of the business. Business strategy relates to the 'HOWS' of the corporate strategy in different functional areas. Operational strategy concerns 'HOWS' of the operational areas of the business strategy. Business strategy is sometimes differentiated from the Operational strategy as the former relates to the macro and the latter to the micro level of activities. Thus, the operational strategy concerns the operational management. As per Lowson (2002) an operations strategy is composed of a pattern of decisions regarding generic factors and includes Core competencies, capabilities and processes, Resources, Technologies, and Key tactical activities vital to support a particular strategy. The decisions for an operations strategy may vary from firm to firm and may cover issues such as selection of competencies, work flows, resources needed, quality levels, human resource levels, facilities and their capacities needed, suppliers required, technologies and general operating systems.

Business strategy, on the other hand, is broad and includes functional strategies related to business such as marketing, finance, HR, besides operations. It provides a plan of action to translate the business objectives to performance. The business strategic management leads to identification of a distinct domain of navigation to obtain competitive advantage. The basic objective is how to compete given the organisational strengths and the weaknesses in the internal and external environment. The business strategy helps to adopt a strategic positioning so that business activities are performed to get an edge over rivals and to provide sustainable operational effectiveness in the complex and dynamic environment that an enterprise is placed. A good business strategy focuses on the core competencies of the unit or factory, aligns with the business objectives and provides a pattern of decisions for various functional areas. The business strategy, thus, can be seen to comprise of sub-sets of strategies covering business process/ functional activities of Finance, Marketing, Manufacturing, Supply Chain System, Quality, Human Resources and Technology. The last of the strategy sub-set is generally related to the firm specifics.

A good business strategy focuses on the core competencies of the unit or factory, aligns with the business objectives and provides a pattern of decisions for various functional areas.

SWOT analysis as covered in the previous sections provides a scan of the internal and external environment. It becomes the starting point. The scanning helps to understand clearly the importance and the nature of operations and the core competencies available, the extent of technology in usage and the key management processes as these exist. The scanning as discussed concerns organisational aspects. There can be additions to the same as related to a specific industry firm or

an enterprise. For example, in the SME pharmaceutical industry market is clearly divided into two target groups. The first market comprises of big pharma companies and the second constitutes of the end users, that is the doctors who prescribe the drugs to their patients. Enterprise has therefore to focus on these educated and well-informed market segments for positioning and promotion of their products. It is therefore understandable that most SMEs endeavour to form alliances with larger pharma companies. Here management takes precedence over technology to achieve success. But in many cases, such as software consultancies or healthcare systems (hospitals), it is the technology which scores over the management systems. Technology becomes the 'strength' point to be exploited.

Formulation of Business Strategy has three discrete stages:

- Developing the strategy
- Implementing the strategy
- Monitoring the strategy implementation

Developing the strategy: While elaborating theme of competitive advantage in the context of a firm or organisation, Porter(1998) refers to competitive strategy and points out that the basic philosophy of strategy comprises of taking necessary steps to check and take counter measures against the competition in business areas so that the profitability of the company and its growth are protected. The development of strategy therefore takes into account, first the core competencies of the firm which can be largely gathered from the SWOT analysis, secondly, the opportunities available and, thirdly, the weaknesses of the competition. It calls for a positive differentiation with the competition to be successful. For an SME it would be unwise to jump into competition with an established large manufacturer without creating a perceptible difference on some of the parameters, such as price or quality or service or delivery or performance.

Development of strategy takes into account the core competencies of the firm, the opportunities available and the weaknesses of the competition.

Each of the sub-sets of the business strategies (Manufacturing, Marketing, HR, Technology, Supply Chain System and Finance) can be considered to comprise of Key Performance Areas (KPAs) for better and systematic analysis. Identification of KPAs, Prem Vrat et. al(1998) explain, should be a thorough exercise so as to include all important areas of performance. The strategy-policies can then be formulated for each of the KPAs. For a general SME these are tabulated in Table 1.

Implementing the strategy: The implementation calls for several steps. Foremost it calls for checks to determine that there is proper alignment with the corporate strategy to achieve the mission objectives. The strategic steps not in alignment are to be discarded. Any organisation has multi objectives to be achieved. These have their own priorities. The expected performance and availability of resources have been cast accordingly. The business strategies should also project the same priorities. The business strategy has several sub-sets. It is also necessary that there is horizontal alignment with these sub-set strategies, that is, there is no conflict between the strategic steps proposed and each of them compliments each other.

The strategy so formulated requires formal documentation so that the same can be used for communication down the line as well as to review the progress. The communication is important as the employees have got to know the seriousness of the same from the point of view of the management. A proper communication makes them a part of the exercise so that they consider the goals as their own. The employees feel privileged that they are a part of the organisation. In this respect, each employee should be made aware of the importance of each action.

The operation strategy flows from the business strategy and is a translation in quantitative terms. It is desirable that the implementation of the two is taken up simultaneously.

It is necessary that senior executives are made responsible for the implementation, to carry out the implementation within the constraints of time and financial resources. It is therefore necessary that they are provided full support by the organisation.

Monitoring strategy implementation: From the point of view of real benefits the monitoring of the implementation of strategic policies is more important as otherwise the development of the strategy will remain on paper. The monitoring calls for establishing a communication system so that the reports of the performances against the strategic steps are received on regular basis. The monitoring of strategic steps should always be carried out at the topmost level so that actions can be taken against shortfalls. Simultaneously it may be necessary to revise the allocation of resources or modify the policies in case results are not to satisfaction. The monitoring therefore anticipates:

Table 1: A Framework of Business Strategies for SME

Strategy	KPAs	Strategic Steps /Policies
Manufacturing	Processes	"General, Multifunctional suit-able for small batch size manufacturing"
	Product profile	Large variety of models of same product with minor modifications without affecting basic performance
	Flexibility	Fast change to new model
		Fast capability to increase volume of a batch under processing
	Infrastructure	To support process, product profile and flexibility
		Limited role to install specialisation
	Quality	No compromise on quality related to performance; Eco-nomies of Scale
	Focused Factory	Streamline the process flow
		Align all the systems
		High productivity and low cost of manufacturing
Human Resource	Skills	Develop multiple skills
		Develop mastercraftsmanship to produce high quality
	Experience	Reduce turnover through moti-vation and financial incentives
	Employee Relationship	Develop strong employee loyalty
		Encourage empwerment
		Encourage participation in deci-sion making
Marketing	Product	Unique brands to a large customer or a cluster of customers
		Multiple brands
	Positioning	To meet unmet demand of customers
		To meet unsatisfied demand of customers
		To create a niche market
	Placement	To cater to a large number of small customers or traders in the retail trade
		To align with a large customer and supply as per his brand and specification
		To explore global market presently with high priced products and compete
	Pricing	To offer advantage of low prices resuting from low cost of manufacturing
		Vary prices as per the diversity in the model offered.
	Promotion	Through customer service
		Through fast delivery
		Through unmet demand of customers
		Through unique brands
		Through individual customisation
	CRM	Strong customer data on preferences
		Developing strong interface
		Integeration of customer needs with product development
		Open door policy for key customers
Technology	Product Development	Fast cycle of development; use of CAD
		Integerate customer needs through continuous interaction
		Continuous programmes on cost reduction
		In built quality in design
		Thorough testing before supply
	Process Technology	Flexible systems
		Multi-purpose systems
	IT	Extensive use of IT systems
Supply Chain System Suppliers		Develop small suppliers with less reliance on large ones
		Delivery on time and quality as prime criteria of suppliers
		Flexibility to change volume or switch over to new models
		Outsourcing of non-core competencies to get strategic alliances
		Trade-off between supplies and outsourcing payments
		Minimum of two suppliers for an item
	Logistics	Customisation of supply channels
		Safe delivery on time to be main criteria of performance
	Location of suppliers	Location nearest to consumption centres
Finance	Receivables	Strong controls and developments of norms
		Stoppage of further processing of orders in case receivables exceed norms
		Owner-manager to monitor the receivables
		Return of goods from dealer customers to be controlled and permitted in rare cases
	Stocks	Bare minimum inventories with the firm and at suppliers
		Goods at dealers to be monitored and supplies to be stopped in case of low sales
		No advance production for anticipation of orders
	Expense control	Strict control; norms to be fixed
	Plant Purchase	Limited to general purpose within the capacity demand

Contd.

- A performance measurement system
- A management information system
- A formal organisational structure

The review should be carried out at fixed regular intervals so that a discipline of priorities is maintained.

From Success to Disaster: For an SME, the path from established success to disaster is fast. It occurs mostly as discussed in previous sections from financial mismanagement in terms of missing or slack controls on receivables. Availability of business is never a constraint. An SME can always nibble at the large shares of corporations and prove advantageous over the unorganised/tiny sectors in attributes of product quality and service to customers. In his increasing ambition to grow and take advantage of the available business opportunities, the owner-manager ignores the receivable norms and extends credit to his customers. He lands himself in a position that he cannot meet the financial commitments to suppliers (payments for supplies), regulators(statutory payments) and even employees (salaries). Then the dealer-customers start returning goods for poor quality, although thr real reasons are their inability to clear the outstandings. SME has no choice except to accept the same, unlike large corporations who can bank on alternate choice of multi-products, large network of customers and advice of its professional executives. An SME rushes to banks for loans or to mortgage its property.

Table 2: Critical Success Indicators and their Measures

CSI	Measures Benchmark Ratio
Receivables	No of days of average sales
	Total amount outstanding
Inventories	No of days of finished stock as averagesales
	No of days of unsold stock at dealers as average sales
	No of days of Raw materials and WIP as average sales
Manufacturing Cost	Total cost as ratio of sale-price
	Material cost as ratio of sale-price
Market Share	Niche market achieved as ratio of total sales
	Value of orders not supplied on time as ratio of total sales
	Average cycle time of execution
Quality	Value of process rejections as ratio of manufacturing cost
	Value of defective goods received from market as ratio of sales
Technology	Status of flexibility for volume change
	Status of flexibility for volume change model change
Logistics	Cost of distribution as ratio of total sales
	Cost of freight as ratio of total sales

An SME can save itself from this situation with an approach based on strategy and developing monitoring parameters which provide signals of lurking disaster. These parameters are in the form of Critical Success Indicators (CSI). These are primary and top measures which immediately inform the extent of performance of an organisation. CSIs are directly related to the business strategy, business plan and performance objectives. Critical indicators are the most effective of performance indicators from a multitude of measures so that it is the vital areas whose performance gets projected. These are designed and selected in such a way so as to provide a readily available measure of performance. These are to be used by the top most management levels. Each of the CSIs requires a measure and a benchmark for comparison. It is desirable that the measures are quantitative in nature. However, in case this is not so possible, a comparative scale of gradation can be used. The element of subjectivity inherent in such an approach can be minimised through assessment being carried out by a group of executives. Benchmark works as a standard. It is necessary so that a comparison can be made to arrive at the degree of accomplishment. Benchmark projects the performance aimed at and represents the potential possible within the constraints of resources and a marketing environment. Comparison is in the form of percent ratio achievement of the benchmark.

In the context of SMEs under discussion the proposed CSIs and their measure are tabulated in Table 2. These, it suggested, be monitored on a monthly basis. The CSIs mentioned are based on organisational aspects of an SME. However, there can be a need for additional specifics based on the customised need of a firm or product requirements. These can be added to the list. It is recommended that the CSIs are restricted to a quantity not exceeding ten so that monitoring is more meaningful.

Conclusions

SMEs are the backbone of many a large industry. These provide support in the form of goods and services. Firms in FMCGs, the automobile sector and pharmaceuticals, are dependent on the small industry in a major way. The small industry is known for its low costs, low overheads, capability of innovativeness, flexibility in operations and in providing fast response to customers. There exists a strong motivation for the start of an SME. It provides independence and an opportunity to convert your dreams into realities. It generates a forum where all members of the family get gainfully occupied. A vast

majority of the small industry is family owned. However, these have also a high rate of failure. An average firm has a short life not exceeding five years. Inefficient handling of finances, especially in areas of receivables, happens to be the major cause of failures. Unfortunately, the owner-manager comes to appreciate the same only after the disaster has struck. This happens as the small unit has not formulated its business strategy. It is not aware of its strengths or the opportunities available so that it can draw up plans to exploit the business environment to its advantage. It is not knowledgeable either about its weaknesses and the lurking threats that it can steer away from. No other sector needs to know the essentials of management as badly as the small sector.

Globalisation has brought opportunities, many of which are more suited to the small industry. The service sector has opened up new vistas. SMEs have to understand the paradigm of change. There is indeed no shortage of business for a small sector unit. Formulation of a business strategy also calls for establishing Critical Success Indicators. A proper business plan and its execution will prove the present high rate of failure to be a myth.

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The great accomplishments of man have resulted from the transmission of ideas and enthusiasm.

– Thomas J. Watson

Feature

Linking Performance Measures with TQM Factors & Practices

R.L. Shrivastava, S.S. Bhagade & R.R. Lakhe

A lot of research has gone into identifying TQM factors and practices that should lead an organisation to performance improvement. However, even today, a clear picture as regards TQM factors vis-à-vis organisation performance measures is far from emerging. Moreover, the cultural, radial, educational and economical differences only show that a universally applicable relationship is nothing but a myth. At best, such a relationship may be experimented with at the country level. This paper makes at attempt in this direction. Through a survey of small, medium and large Indian industries, an effort has been made to establish a link between performance measures and TQM factors, typically for an Indian environment.

R.L. Shrivastava is Dean (planning & development) and Asst. Prof of Mechanical Engg. at Yeshwantrao Chavan College of Engineering, S.S. Bhagade is Reader at Laxminarayan Institute of Technology (LIT), Nagpur and R.R. Lakhe is Director, Shreyas Quality Management Systems (SQMS), Nagpur.

Quality improvement is a highly desired objective in the fiercely competitive international business world, yet it remains elusive to many organisations. Improved quality is commonly thought to reduce cost, as doing things correctly the first time eliminates waste. (Juran, 1989). An approach towards improvement, Total Quality Management (TQM) helps in eliminating waste, reducing variations and ensures continuous improvement. TQM is an integrative philosophy of management for continuously improving the quality of products and processes to achieve customer satisfaction (Mohanty & Lakhe, 1944). The practices involved in TQM have developed from traditional quality control philosophies and practices first proposed by Shewart. These have diversified since the 1950s publications of Juran & Gryna into a host of fields, including supplier management, employee involvement, teamwork, leadership, customer focus, service and strategic planning (Lakhe & Shrivastava, 2000).

Although TQM literature is still based on personal prescriptions of a relatively small number of established writers and practitioners, including Deming, Juran, Crossby and Ishikawa, no consensus on the approach has really emerged. Furthermore, inspite of the significant increase in research into TQM in the last decade, there is little evidence of collaboration of the accepted theories through hard research work. This has led to a shift in emphasis within literature towards a general framework for understanding TQM. These frameworks have aimed to provide a basis for diagnostic assessments of organisational TQM practices for the purpose of directing breakthrough and continuous improvement action.

The literature has also focused on factors, that contribute to the success of TQM. Lu and Sohal, (1993) identified improvement opportunities in the approaches adopted by Australian organisations and also listed the factors likely to contribute to quality improvement. Kasul and Motwani (1995) identify critical factors supporting

performance measurements of TQM in the manufacturing environment. The study by Sink (1991) shows that the performance of an organisation system is composed of seven inter related criteria; effectiveness, efficiency, total quality, productivity, quality of work life, innovation and financial performance. Many researchers (Mohanty & Lakhe, 1998, Ross, 1993) have discussed the importance of critical factors such as top management involvement, leadership for quality, supplier quality management, process management, employee training, and employee involvement in quality.

The literature implies that as the decision-markers of an organisation focus on better management of critical factors, improvements will occur in quality performance, and ultimately result in improved financial performance for the organisation. Madhu et. al., (1996) attempted an empirical study to test if there is any significant association between quality dimensions and organisational performance. Venkatraman and Ramanujan (1996) focused their study on different approaches to the measurement of business performance in strategy research and the benefits and limitations of each approach. To date, there have been only a few systematic attempts to organize and synthesize the various sets of quality improvement factors identified by different authors, and to correlate these with the organisation's performance. The objective of this paper is to find out the impact of quality improvement factors on organisational performance.

Literature Review

Although there is growing awareness that a well-designed and well-executed TQM process is one of the most effective routes to increased product and service quality, productivity and profitability, many organisations are still mired in "quality confusion". Indeed, the meaning of the term 'quality' itself is still being debated. Due to this ambiguity, people's reactions to TQM vary as a function of their own beliefs and experiences.

The transformation to a TQM organisation depends on the extent to which firms successfully implement certain quality management practices. A research study on the critical success factors of TQM implementation is needed because there appears to be wide variation in TQM results/benefits. TQM is seen by some as an extension of scientific management, by others in terms of systems theory, and by still others as an altogether new paradigm for management. Khanna et. al., (2002) examined TQM in relation to the mechanistic, organisational, and cultural models of the TQM practice and management theory in the Indian automobile sector. It is evident that very few organisations have achieved significant or even tangible improvements in quality, productivity, competitiveness or financial returns (Brown 1999). Because of the wide variation in TQM results, the search for the genuine keys to success in TQM implementation has become a matter of deep concern.

TQM is seen by some as an extension of scientific management, by others in terms of systems theory, and by still others a new paradigm for management.

Various pioneering researchers have made significant contributions towards the design, development and application of the TQM system. Many surveys have been carried out and their results documented, resulting in a substantial increase in quality consciousness over the past decade (Wali et. al., 2000). The TQM models provide diverse analogues for explaining the management of organisations and highlight different issues that underpin the practice of TQM. The models advocate a humanistic, systems approach to TQM, while espousing the need for fundamental cultural changes at all levels of the organisation.

The question that arises is not whether all components are required for success, but whether there is some necessary pairing among the elements. For example, one could speculate that certain organic components of TQM can only have a positive influence on quality if particular mechanistic aspects also have been established. This might explain why work teams can generate improvements more effectively when they are acting on well defined and stable processes (Adam et. al., 1997; Ahire et.al., 1996). However, much of the attributed "success rate" is mixed. For example, a study by Forker (1996) examined the contribution of quality management on business performance and concluded that quality management helps a firm gain competitive advantage by delivering goods to the marketplace that meet customer needs. A study by Powell (1995) found that most features generally associated with TQM, such as quality training, process, improvement, and benchmarking, do not generally produce competitive advantage, but that certain tacit, behavioural, imperfectly imitable features can produce competitive advantage.

Research Objective, Experimental Design and Procedure

Research objective

The main objective of this research is to investigate

which of the identified TQM elements will have a significant impact on the organisation's performance.

The literature is abundant with studies that aim to identify the elements and factors constituting TQM. TQM suggests customer focus, top management leadership, statistical thinking, continuous improvement, problem solving and work force training (Evans and Lindsay, 1993). It often includes variation reduction and employee empowerment as Key TQM attributes. The organisational performance measures reflected through quality, customer satisfaction, profitability, timeliness, and financial business results are influenced by these TQM factors. The primary interest in this study is which combination of TQM factors lead to highest performance. How is performance defined? In this study, the interest is in identifying TQM factors that can predict organisational performance. The specific hypothesis for this research is— "TQM factors correlate to organisation performance improvement positively".

Experimental Design

The dependent variables, i.e. the TQM elements, are selected from the Mohanty & Lakhe (1998) diagnostic instrument. It outlines the four diversions as "Pro-active Business Orientation", "Internal Support", "competitive Assessment" and "Participatory Orientation". The internal consistency for the instrument is established using Cronbach's alpha as a reliability coefficient and found to be greater than 0.70, indicating that the scales developed are reliable. The criterion validity of 0.78 and eigen value greater than 1.0 indicates the construct validity of the scale. The critical dimensions of TQM identified are outlined in Table 1.

Factor 1, accounting for 39.9 per cent of common variance, is named 'Proactive Business Orientation'. Developing a structure of quality planning framework for initiating strategy-focused management actions, having a strong quality improvement infrastructure, an aggressive technology policy, creativity and innovations in product design and sound financial status, all relate to such an orientation. A critical look into all these items reveals that they are, in fact, unique resources for a business enterprise. Strong and captive possessions of these unique resources by any enterprise will create an asymmetry with reference to others possessing no such uniqueness. It should be noted that such an asymmetric enterprise will be able to take early competitive advantages, and will continue to maintain the leadership position in terms of cost, quality, time, product, technology, distribution channel, flexibility, etc.

Table 1: Critical Dimensions Affecting TQM implementation

Item	Definition
Organization size	Size of the organisation whether large or small in terms of number of employees, turnover, etc.
Top management support	Commitment to implement TQM by investing time and money, and providing coaching and guidance to all in the organisation
Team building approach	Extent to which quality circle, total employee involvement and cross-functional deployment are used.
Communication	The channel of communication, and degree of transparency and feedback support
Flexibility	Degree of responsiveness to change systems and procedures
Organisational goals	The long and short term goals of the organisation
Structures of planning framework	The extent of strategic quality planning and connectivity across the organisation
Infrastructure	The extent of service and support systems compatible with the company requirements
Management risk taking ability	The degree to which management can take financial risks
Competitive strategy	Extent of competitor scanning and active perusal of bench-marking performance indicators
Technology policy	The degree of aggressiveness of the company's policy on technology adaptation, transfer and assimilation
Customer interaction	Extent of supplier customer coordination
Employee relation	Extent of employee involvement in quality problem solving
Product design	Degree of emphasis on reliability, manufacturing ability and maintainability, etc.
Vendor relation	Degree of participation of vendors in quality assurance, value engineering and inventory control
Compatibility and coordination	Compatibility and coordination of quality management policies and programmes within the company between various levels and layers
Financial position	Ability of the organisation to invest in different resources
Recognition and reward system	The policies and practices towards recognition and rewarding good work

The second factor, named 'Internal Support', accounts for 7.8 per cent of common variance, and represents the extent of mutual support for TQM within the organisation. Sustained and active top management support, healthy employee and customer relations, and the proper system of appreciation and recognition for good work are collectively the key determinants for successful TQM implementation. A TQM project can produce lasting results, if and only if, top management

invests their time and energy in revitalizing the organisation. Creating a total organisational mind-set through cross-functional working patterns and institutionalizing such patterns to strive for quality in/of management must impact the people at all levels. This factor can be interpreted as the organisational culture. This culture will trigger off an integrated approach in achieving and sustaining high quality output and concern regarding the continuous improvement of processes in all functions of the organisation.

The third factor explains that 7.2 per cent of the common variance appears to indicate the market and competitive needs. It depicts an organisation's policy with regard to gathering and analyzing information on customers and competitors. Competitive strategy, management risk taking ability and vendor relations are the items included in this factor. Typically, larger organizations engage in formal interaction with vendors, and continuously engage in assessing competitor moves, and are more likely to implement TQM successfully, This factor - we term it 'Competitive assessment' has the following implications:

- Recognition that organisations must adapt to a future of continuous change
- Strategic initiatives can become successful, only if organisations adopt a competition-driven agenda, and reorient the priorities and refocus the resources around the items in this factor.

The final factor, accounting for 6.9 per cent of the common variance, represents the 'participatory nature of organisations'. Loaded on this factor are items, such as: communication and team building approach. Establishing appropriate channels of communications with multiple stakeholders will help in successful implementation of TQM programmes. The participation of multiple stakeholders in TQM implementation is central to developing the necessary depth of commitment throughout all levels of the organisation. Defining the clear-cut modalities, and following them will build morale throughout the organisation.

The literature review indicates wide variation in approaches and definitions of an organisation's performance measures. This research has, therefore, undertaken to develop an appropriate approach and define the organisation's performance measures. A typology was used that synthesized the characteristics of performance measures. In order to ensure that the outputs of the process are appropriate, the typology identified the characteristics of well designed performance measures and appropriate dimensions of performance. This framework is used to evaluate current strategic organisation performance measures. These are outlined in Table 2.

Table 2: Critical Dimensions of Organisation Performance

Quality	Time	Business Results	Customer satis-faction	Human resources
• Product perfor-mance	• Lead time	• Cash flow	• Market share	• Employee relationship
• Delivery reliability	• Delivery reliability	• Market share	• Service	• Employee involve-ment
• Waste	• Process through-put time	• Overhead cost reduction	• Image	• Workforce
• Depend-ability	• Process time	• Inventory perfor-mance	• Integ-ration with custo-mers	• Employee skills
• Innova-tion	• Producti-vity	• Cost control	• Compe-titive-ness	• Learning
	• Cycle time	• Sales	• Inno-vation	• Labour efficiency
	• Delivery speed	• Profit-ability	• Delivery reli-ability	• Quality of work life
	• Labour efficiency	• Efficiency		• Resources utilization
	• Resource utilization	• Product cost reduction		• Producti-vity

After the pioneering paper of Saraph et.al. (1989), research in production and quality engineering focused on using the science approach of developing instruments for measurement purpose. A similar approach was used by Mohanty and Lakhe (1998) in developing TQM dimensions.

Research Process

A survey method using the instrument outlined above is used to test the hypothesis. The data collected was factor analysed for establishing the reliability and validity of the instrument. To test the causal relationship multiple regression analysis was carried out. The main reason for employing multiple regression is to determine the minimum number of a set of variables that is most strongly related to the dependent variable, and to estimate the percentage of variations in the dependent variable explained by these variables.

Research Hypothesis

Following the literature review, the following

hypothesis has been articulated for testing.

H : TQM has a significant and positive impact on organisation performance.

Sample Size and Response Rate

It is important to know the nature of the sampling frame. A study that is based completely on a sample drawn from one company cannot be used to generalize about the industry. Generalizations can only be drawn when random samples are used. Awang (1998) surveyed only 65 organisations in December 1996, and Idris (1997) surveyed 76 organisations that were implementing TQM. However, in the present research, a sample size of 258 companies was chosen for the final survey.

This figure represents the total number of TQM implementation firms from the main sources, that is National Productivity Council (NPC), The (I) (IEI), Bureau of Indian Standards, local industries associations, etc. It was possible to establish which firms had implemented or were working towards TQM, Meanwhile, other sources are customers' lists given by established TQM consultant firms such as SQMS and lists supplied by colleagues, industrial fellows and other firms. The 258 companies selected for the survey were considered highly representative of the total population. In the pilot study, the response rate was 47 per cent, whereas a response rate of 57 per cent was recorded in the final study.

Sampling adequacy is tested using the Kaiser-Meyer-Olkin test. The Kaiser-Meyer-Olkin index for sampling adequacy was found to be 0.76968, which is adequate, as scores above 0.7 are considered good for proceeding to factor analysis.

Analysis of Data

The data collected was subject to factor analysis using the SPSSX 2-1 package. Factor analysis focuses on the whole set of interrelationships displayed by the variables in the data, and it does not treat one or more of the variables as dependent variables. The basic assumption of factor analysis is that there exists underlying dimensions, of factors, that can be used to explain complex phenomena. It represents relationships among sets of variables parsimoniously, i.e. it explains the observed correlation by using as few factors as possible. At a mathematical level, a factor is simply a linear combination of variables. The linear combination is not chosen arbitrarily, but is selected to capture the essence of the data.

The 18-item instrument was subject to principal component VARIMAX rotation using the SPSSX programme. Hair et. al., (1987) have recommended this method for obtaining a simple orthogonal solution. The use of orthogonal rotation was based upon the assumption that the broad ranging scale developed here permits the subjects to report the importance of factors differently as between its various components. This assumption was checked by examining whether the extracted factors or derived dimensions met each and all of the following three criteria:

The pattern of item-factor loading should be such that items load high on a single vector and relatively low on all other vectors. As suggested by Nunnally (1978) factor loading of 70:30 was used as the minimally acceptable cut off point. There should be higher inter-item correlation within factors than between them, and acceptable levels of internal consistency with each factor.

The dimensions derived from factor structures should have low shared variance.

Reliability and Validity Tests

The reliability analysis of a questionnaire determines its ability to yield consistent results. Reliability was considered as internal consistency; which is the degree of inter-correlation among the items which comprise a scale (Flynn et al, 1994). Internal consistency can be established using a reliability coefficient, such as Cronbach's Alpha. Alpha is the average of the correlation coefficient of each item with each other item (Nunnally 1978). The Cronbach's (1951) alpha for each factor was calculated and found to be equal to or greater than 0.70, indicating that the scales developed are reliable.

The validity of a measure refers to the extent to which it measures what is intended to be measured. Construct validity represents the adequacy with which a specific domain of content has been sampled. A measure has content validity if there is general agreement among the subjects that the questionnaire has measurement items that cover all aspects of the variable being measured. Since the measures developed here are based on exhaustive literature survey and evaluated critically by experts in the field, they have content validity. Criterion validity is estimated using a validity coefficient which is the correlation between predictor and criterion score. A validity coefficient is an index of how well criterion scores can be predicted from the instrument score. The criterion related validity was evaluated by examining the multiple correlation coefficient computed for the four factors and the quality performance of the organisation. The quality performance

rating was invited from the participants. The multiple correlation coefficient was found to be 0.78, indicating that the measures have a high degree of criterion related validity when taken together.

Finally, construct validity measures the extent to which the items in the scale measure the same construct. It was established through the use of principal component factor analysis. The factor matrices showed that they were uni-factorial with eigen values greater than the accepted criterion of 1.0, indicating that the scales content in the questionnaire have construct validity. The results obtained for TQM dimensions collaborated well with Mohanty and Lakhe (1998).

Principal components analysis of the data collected revealed a weak general factor, suggesting that the scale was multidimensional in nature for organisation performance. Upon subsequent rotation, four interpretable factors were obtained. Table 1 presents the list of critical items affecting TQM implementation in Indian manufacturing firms.

Table 3: Varimax rotated factor matrix on samples data

Variable	Commu-nality		Factor	Eigen value	% of var	Cum %
OPM1	0.75513	*	I	5.28509	28.9	28.9
OPM2	0.68274	*	II	1.50298	9.8	38.7
OPM3	0.52895	*	III	1.40418	8.2	46.9
OPM4	0.58615	*	IV	1,33556	6.9	53.8
OPM5	0.70037	*	V	1.00098	5.8	59.6
OPM6	0.70296	*				
OPM7	0.69830	*				
OPM8	0.81667	*				
OPM9	0.55833	*				
OPM1O	0.58255	*				
OPM11	0.64488	*				
OPM12	0.61606	*				
OPM13	0.62572	*				
OPM14	0.53878	*				
OPM15	0.68832	*				
OPM16	0.68120	*				
OPM17	0.56829	*				
OPM18	0.67387	*				

The VARIMAX rotated factor matrix for the 18 items of organisation performance measurement is reported in Table 3. Factor loading is given in Table 4. This analysis indicates that the organisation's performance clusters around five factors. These factors are the breadth levers of the TQM process implementation. TQM implementation issues must penetrate to an organisation's core, fundamentally focusing on 18 items that will facilitate leverage for attaining long-term organisation-wide impacts. Further, these items are organized around five significant factors, and these factors incorporate the holistic paradigm of the organisation's performance.

Table 4: Factor loading

Variable	Quality I	Time II	Customer Satisfaction III	Human Resource IV	Business Results V
Scrap level	0.728				
Rework level	0.716				
Waste reduction	0.629				
Throughput time		0.618			
Delivery speed		0.612			
Supplier Lead time		0.528			
Customer complaints			0.892		
Customer satisfaction			0.829		
Market share			0.692		
Competitive position			0.563		
Labour efficiency				0.535	
Multi-skilled work force				0.482	
Employee satisfaction				0.446	
Quality of work life				0.434	
Profitability					0.787
Internal & External performance					0.622
Business position					0.754
Cost					0.812

Results and Discussion

Table 5 presents the correlation results of the organisation's performance measures and TQM dimensions.

Quality performance showed significant relationship with Proactive Business Orientation (r = 0.250) and Competitive Assessment (r = 0.70). Customer Satisfaction Performance is influenced by Pro-active Business Orientation (r = 0.080), Internal Support (r = 0.040) and Participatory Orientation (r = 0.210). Internal Support and Participatory Orientation have

Table 5: Correlation Matrix of Organisation's Performance with TQM Dimension

	Pro-active Business Orientation	Internal support	Competitive Assessment	Participatory Orientation
Quality Performance	0.250**	0.071	0.170*	0.043
Customer Satisfaction	0.080*	0.040**	0.182	0.210**
Business Results	0.110	0.251*	0.060	0.189*
Human Resource	0.050	0.053**	–0.004	0.090**
Time	0.011*	0.081*	0.062**	0.262

*P <0.05 **P <0.01

Table 6: Multiple Regression Analysis Results—TQM Dimensions (Predictors) and Organisational Performance Measures (Criterion Variables)

TQM Dimensions → **Organisation Performance Measures ↓**	**Proactive Business Orientation** (Structure of Planning Framework, Technology Policy, Organisational goals, Infrastructure, Product Design Flexibility, Financial Position)	**Internal support** Top Management Support, Employee Relation, Compatibility & Coordination, Organisation size, Customer Interaction, Recognition & Reward Systems	**Competitive Assessment** Competitive Strategy, Management Risk Taking Ability, Vendor Relations,	**Participatory Orientation** Communication, Team Building Approach	**Intercept**	**Multiple R**	**F. Value**
1. Quality Performance (Product quality; Delivery; Waste reduction; Innovation)	0.38(2.65)**	0.14(1.49)*	0.31 (0.50)	0.41(0.89)	4.l162	0.236	1.1466*
2. Customer Satisfaction (Image; Complaints; Repeatability of order)	0.72(1.49)**	0.39(2.04)	0.61(0.43)*	0.47(2.36)**	3.915	0.282	1.6824
3. Business Results (Inventory Reduction, Cost Reduction, Profitability)	0.49(1.89)**	0.05(2.18)	0.72(1.94)**	0.37(6.02)	3.765	0.349	2.7077**
4. Human Resource (Employee Satisfaction; Quality of work life; Work force involvement)	–0.3?–(2.49)**	0.68(1.49)**	–0.25–(1.14)*	0.36(1.00)**	4.171	1.256	1.3652*
5. Time (Process Time; Productivity; Labour efficiency; Resource utilization)	0.48(1.69)**	0.34(0.28)*	0.26(2.18)	0.17(1.73)	3.527	0.279	0.9650

*P <0.05 **P <0.01

shown significant relation with Business results, while Human Resource Performance also is strongly correlated with these. Time Performance has influence of Pro-active Business Orientation (r = 0.11), Internal Support (r = 0.081) and Competitive Assessment (r = 0.062). Surprisingly, Human Performance has negative correlation with the Competitive Assessment dimension of TQM.

In order to investigate the effects and magnitudes of more than one TQM dimension (Predictors) on various organisational performance measures (Criterion Variables), regression analysis was performed. The multiple regression results are presented in Table 6. It is evident that all TQM dimensions significantly influenced organisation performance measures. The analysis revealed that quality performance is significantly influenced by proactive business orientation (t = 2.65, P 0.01) and Internal Support (t = 1.04, P 0.05).

The organisation's customer satisfaction is significantly influenced by Pro-active Business Orientation

(t = 1.49, P 0.01), competitive Assessment (t = 2.04, P 0.05) and Participatory Orientation (t = 2.36, P 0.01).

Business Results, as depicted through financial measures such as profitability, cost reduction, inventory reduction, are significantly influenced by Pro-active Business Orientation (t = 1.89, P 0.01). Internal Support and Participatory Orientation do not show significant influence on Business Results.

Human Resource Performance, evident through employee satisfaction, quality of work life, work force involvement, is influenced significantly by all the four TQM dimensions. The Time performance of the organisation, as reflected by Process time, Productivity, Labour efficiency and Resource utilization, has significant influence of Internal Support (t = 0.28, P 0.05) and Participatory Orientation (t = 1.73, P 0.01).

Conclusion

This paper has reported the results of an analysis conducted on data collected from small/medium/large sized Indian companies. Specifically, it examined the relationship between quality management practices and organisation performance, and identified a number of significant relationships between TQM practices and organisational performance. For an organisation that is concerned with customer satisfaction, pro-active business orientation and participatory orientation focus are particularly important, as these provide the greatest positive influence. Product design flexibility is an important element of pro-active business. Customer needs vary and therefore flexibility in design is a must. The results are collaborative to the finding of Anderson and Sohal (1999).

Organisations desirous of improving their business results and profitability need to concentrate on competitive assessment and pro-active business. Internal support and participatory orientation do not have a significant impact on business performance, contrary to belief. Assessment of competitive strategies, benchmarking, risk taking ability and good supplier relations propels business results.

Pro-active business orientation has emerged as the strongest quality dimension influencing all the five measures of organisational performance. Structure of planning, setting organisational goals and communicating these at all levels within the organisation, proper up keep of infrastructure and instruments, and achieving financial balance seem to affect all spheres of the organisation and results in improvement in quality performance as well as employee performance. Internal support indicated through good employee relation, co-ordination and recognition and reward system does not bring about a significant impact on customer satisfaction and human resources. Given the attention that quality and TQM progress have received over the past decade and their inherent cost to the organisation, it appears imperative that research into this very area be promoted, not only by researchers but also by the organisation. Unless organisations can view TQM as a strategic tool and feel confident that in the long term, its effect on business performance will be a positive one, organisations will continue to find it difficult to compete in global markets. The findings of this research should help organisations develop an insight in developing their strategies for competitiveness.

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□

I bring my board my toughest problems, not my easiest. I don't want a paperwork board, but one that thinks like owners.

— Paul O'Neill

Feature

Technological Capability Building for Competitiveness of Firms

Momaya K., Sushil & Ajitabh

Technology can play a critical role in the competitiveness of firms, industries and countries. Sustained success in hyper-competitive markets of emerging industries demands strong technological capabilities and competencies. An attempt has been made in this paper to define basic concepts as a starting point to bring clarity. Review of the secondary data as per available international benchmarks revealed many gaps in technological performance. Understanding problems and their root causes can be the first essential step on the journey to find alternatives to enhance capability building. The problems of weak technology capability building in the context of India are based on inputs from experts and brainstorming. Key problems in building technological capabilities were also identified. Finally, key issues have been highlighted and a conceptual framework developed.

Momaya K., is Asst. Prof., Dept. of Management Studies, IIT Delhi, New Delhi. Sushil is Professor, Dept. of Management Studies, IIT Delhi. Ajitabh is Project Associate, Dept. of Management Studies, IIT Delhi.

Science, technology, innovation and entrepreneurship are key to competitiveness in a large country such as India These four were perceived as facets of a '*Wealth Pyramid*'. Science and technology is at the very core of economic development (Ramamurthy, 2003). Technology, a key factor of competitiveness, can play a very positive role in solving many problems and improving productivity, economic prosperity and ultimately, quality of life for the masses in India. Technology may become more important for accelerating the journey of India to its aspirations of becoming an equal player in the global arena as often articulated by the President of India and many thought leaders in industry, academia and government.

While there are some significant achievements, competitiveness and technological performance of India may not be considered very satisfactory by available global indicators such as National Competitiveness Ranking (NCR) and World Competitiveness Yearbook (WCY). India has many achievements in important industries such as agriculture, dairy, defence and space. Still, after more than 55 years post-independence and a decade of liberalization, India is near bottom ranks as per WCY (42 out of 49, much behind China's position 31 in overall competitiveness position, in 2002) (Table 1) (WCY, 2002). Better ranking in NCR may be due to better treatment of human resources in the NCR (NCR, 2002). While we often boast of having the second largest scientific and technical human resources, the country ranks quite low in terms of technological performance. Technological performance as measured on patents and new products that have global success is still very poor. This hints at major problems in technology management in India.

Competitiveness performance of India in emerging industries may not be considered satisfactory. Software, one of the most internationally competitive industries of India, experienced a major crisis in recent downturn. Our competitiveness diagnostics of software firms have

identified many problems and challenges for the firms (Momaya and Ajitabh, 2002). The low competitiveness of firms can be attributed to poor competitiveness and management–related processes and practices. An Analysis of 50 major firms in biotechnology industry in India indicated that it must make quick moves to form a high value base (Bowonder, 2002).

Table 1: Country Competitiveness Ranks for select countries

Country	Competitiveness Rank, 2002	
	WCY	NCR
USA	1	1
Singapore	5	6
Canada	8	10
Australia	14	17
Japan	30	18
Korea	27	24
Malaysia	26	26
China	31	37
India	42	40
No. of Countries	47	59

Source: (WCY, 2002; NCR, 2002)

Technology and Innovation Management is a key to accelerated competitiveness enhancement of countries and firms. Technology has always played a major role in creating the wealth of nations and influencing standards of living and quality of life (Khalil, 2000). Civilizations were built around the use of innovative technology, and some vanished when they lagged in technology. That may be why Japan still invests heavily in technology after a decade of unending tough recession and leads the world on several macro indicators of technology and innovation management (Table 2). Weaknesses in efforts and performance for India and technology thrust of the emerging leaders of China are clear, along with wealth creation by the technology leaders: Japan and USA. Competitiveness in hyper-competitive markets of emerging industries demands strong technological capabilities. Competitiveness is far more an issue of corporate policy than of industrial policy (Hamel and Prahalad, 1996); shouldn't the firms in India take the lead in the revolution to leverage technology in the emerging era?

Firms are expected to play a much more crucial role in such a technology and innovation revolution. While exceptions may exist, large segments of the Indian industry, institutions and society as a whole do not seem to be leveraging technology and innovation that well. This is reflected in the number of macro indicators of technology and related factors for different countries (Table 3). While results and their interpretation are debatable, very poor management of technology in India is visible in the performance on several indicators. Very limited contribution of business for technology capability building is also evident in indicators such as business expenditure on R&D, patents and exports. It is worth noting that since independence most of the R&D investments have been done by the government / public sector.

Table 2: Select Macro Indicators of Technological Competitiveness (2000)

Country	GDP/ person Employed (US $) (PPP)	R&D/ capita (biz.) (US $)	Total R&D/ capita (US $)	Patents granted to residents (1999)	High tech exports (US $m)
India	6,237 (49)	0. 67 (45)	2.4 (46)	633 (22)	1,245 (33)
Japan	52,779 (19)	736.65 (3)	1,170.5 (1)	1,33,960 (2)	1,27,368 (2)
USA	71,858 (2)	705.63 (4)	936.8 (4)	83,907 (3)	1,97,033 (1)
China	7,375 (47)	5.12 (41)	8.5 (43)	3097 (10)	40,837 (9)

Source: WCY, 2002; Note: Rank of the country is in brackets

Limited understanding about the concepts, problems and issues seems to be a root cause of the problem of low leverage of technological capability building for competitiveness across levels in India. We still do not have a feel for real problems and best indicators to evaluate 'technology and innovation management' or 'technology capability building'. The dynamics of accumulating technological capabilities is very relevant to development (Bowonder and Richardson, 2000). An attempt has been made in our research to address the gaps based on synthesis of secondary data and a survey as a prerequisite to understand the dynamics.

Considering the inadequacy of good frameworks, a conceptual framework was developed to form the basis for discussion during research (Fig. 1). The aspirations of making India a developed country will demand competitiveness at all levels: firms, industries and country. Some industries in India such as textiles, gem & jewellary have achieved significant exports leveraging the comparative advantages that India offers, other such as software and pharma are working hard to graduate to competitive advantage. Creating and sustaining strategic competitiveness (Hitt, 2001) will demand that high-end skills and capabilities are developed rapidly.

Table 3: Macro Indicators of Technology and Related Factors

	Unit/ Measures	India	China	Japan	USA	UK	France	Korea
Total exp. on R&D	$ m (2000)	2303	10844	148566	265332	26965	27787	12249
Total exp. on R&D/capita	$	2.4	8.5	1170	937	435	472	261
Biz. Exp. on R&D	$ m (2000)	642	6530	93323	199855	17450	17793	9196
Biz. Exp. on R&D/capita	$ (2000)	0.67	5.12	737	706	293	302	196
Total R&D personnel per capita	2000 FTE/1000	0.2	0.7	7.255		1.607	5.321	2.957
Total R&D percent	FTE	93.8	480	604		145	172	94.3
Total R&D percent	FTE/ 1000	0.1	0.376	4.772		2.437	2.903	2
Tech. Coop.	Rank	35	47	16	2	24	25	27
Dev. & Application of tech	Rank	38	35	29	4	23	27	24
IT Skill	Rank	5	49	38	3	29	28	17
Funding of Tech. Dev.	Rank	35	36	22	2	17	21	26
Hi-tech export	$ m (2000)	1245	40837	127368	197033	72616	59397	53950
Hi-tech export	% of total exp.	4.29	19	28	30	32	24	35
Nobel prize (since 1950)	2001 no.	1	2	6	203	50	11	0
Scientific article	1997 no.	9248	10748	48063	176141	45231	33295	5411
% of Bach. in Telecom & Engg.	1997 %	23.5	72.3	66.5	32.6	34.7	71.5	46.4
Securing Patents Abroad	1999 nos.	192	235	83814	113280	24005	32179	7764
Patents productivity	1999 nos.	4	9	222		29	67	575
No. of patents inforce/1,00,000 People	1999 nos.	1	4	794	456		585	163
Flexibility and Adaptability of People	Rank	25	45	46	2	39	48	26
Quality of life	Rank	43	38	26	10	21	18	32
Value of the society	Rank	36	6	40	1	26	44	21

Source: WCY (2002); FTE = Full Time Employees

Technological capabilities can be an important capability in a competitiveness journey at any level. Key issues in technological capabilities at three important levels are identified in the bottom part of the framework.

This conceptual framework was used as an importat base in selecting and analyzing secondary data, questionnaire survey and problem structuring. The survey feedback from 67 professionals from industry, academia and government in India was used to generate and prioritize ideas given in the problem structure and issues section below. Vast differences in the views from the survey hint that clarity about concepts, their meaning and practical utility is still very low.

Definitions

Some clarity on acceptable definitions of key terms will help improve our reading of this paper. These terms include competitiveness, technology, innovation, technology capabilities and flexibility. Internationally used standard definitions were adapted in most cases. The goal of an organization is to develop its technology capability and enhance its overall competitiveness.

Technology

Technology is so common; yet it is an under defined term. Here technology can be defined as all the knowledge, products, processes, tools, and systems employed in the creation of goods or in providing services. It consists of following interdependent, co-determining and important components: Hardware, Software, Brainware and Know-how (Khalil, 2000). Any individual technology consists of a particular expertise, based on past experience and the technological solution (Irani in IMAE, 2001).

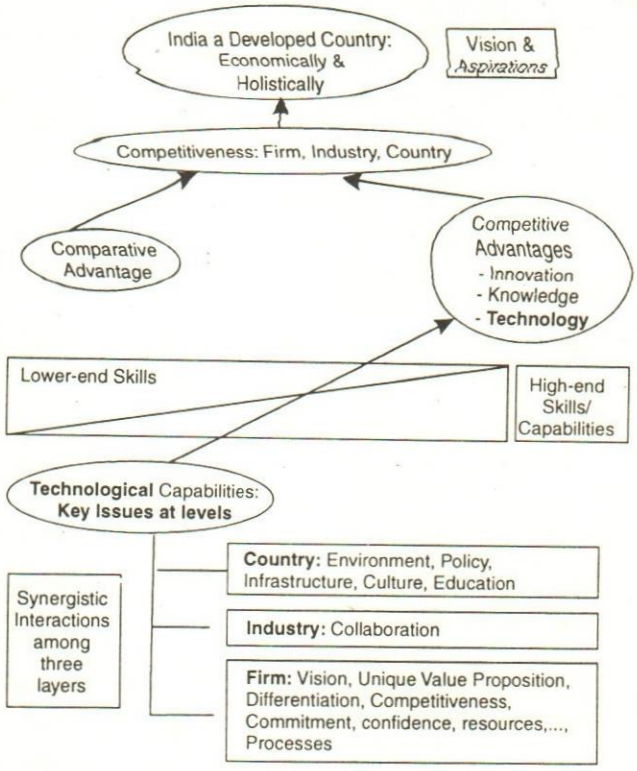

Fig. 1. A Conceptual Framework for Technology Capability Building

Technology Management

Technology management can be defined in many different ways at different levels. Here the term is defined only at the firm level, the area of focus of our research. It is an interdisciplinary field concerned with the planning, development and implementation of technological capabilities to shape and accomplish the operational and strategic objectives of an organization (NRC, 1987). As per the broad scope of technology management that we have adapted (from Tschirky in Sushil and Momaya 2001), the scope ranges from the management of the acquisition and sale of technology, ranging from the management of acquisitions and sale of technology, management of technology development (including R&D) and commercialization (including Production) to management of technology intensive companies.

Technological Capabilities

The notion of technological capabilities attempts to capture the great variety of knowledge and skills needed to acquire, assimilate, use, adapt, change and create technology. It goes well beyond engineering and technical know-how to include knowledge of organizational structures and procedures as much as knowledge of behavioural patterns, e.g. of workers and customers. Firms need certain complementary assets and capabilities in order to create, mobilize and improve their technological capabilities, among which may be noted organizational flexibility, finance, quality of human resources, sophistication of support services and of the

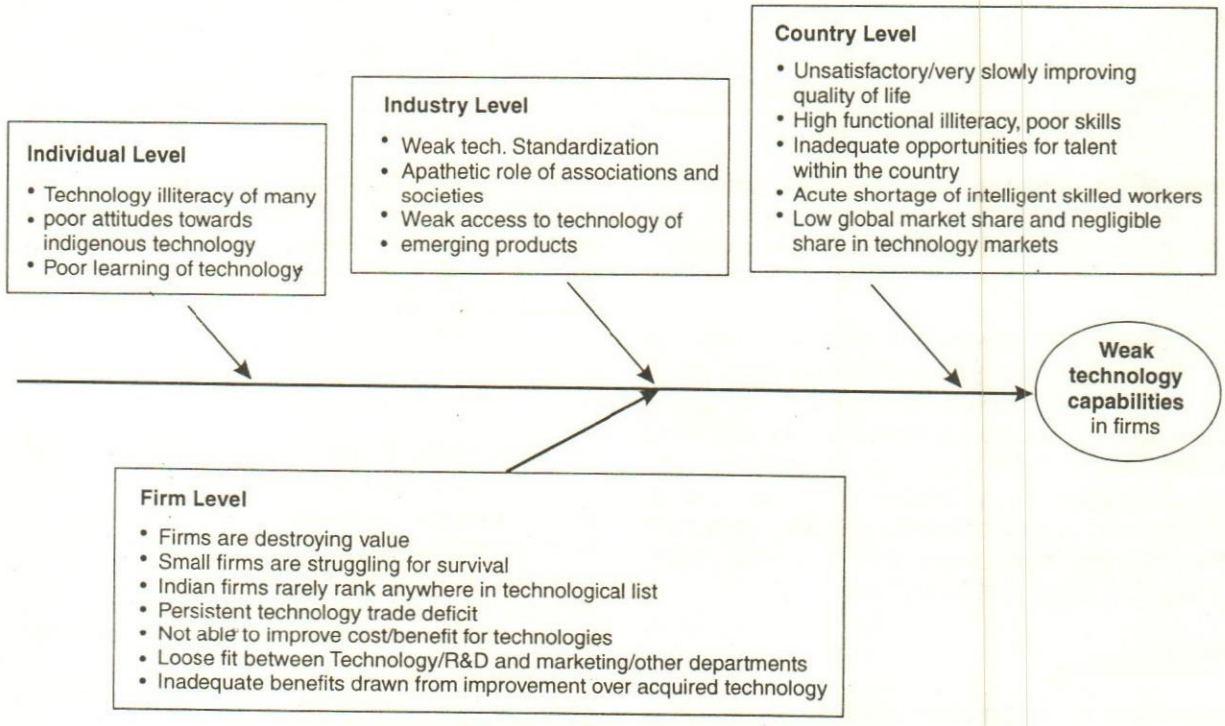

Fig. 2. Root Cause Diagram of Problem Structure

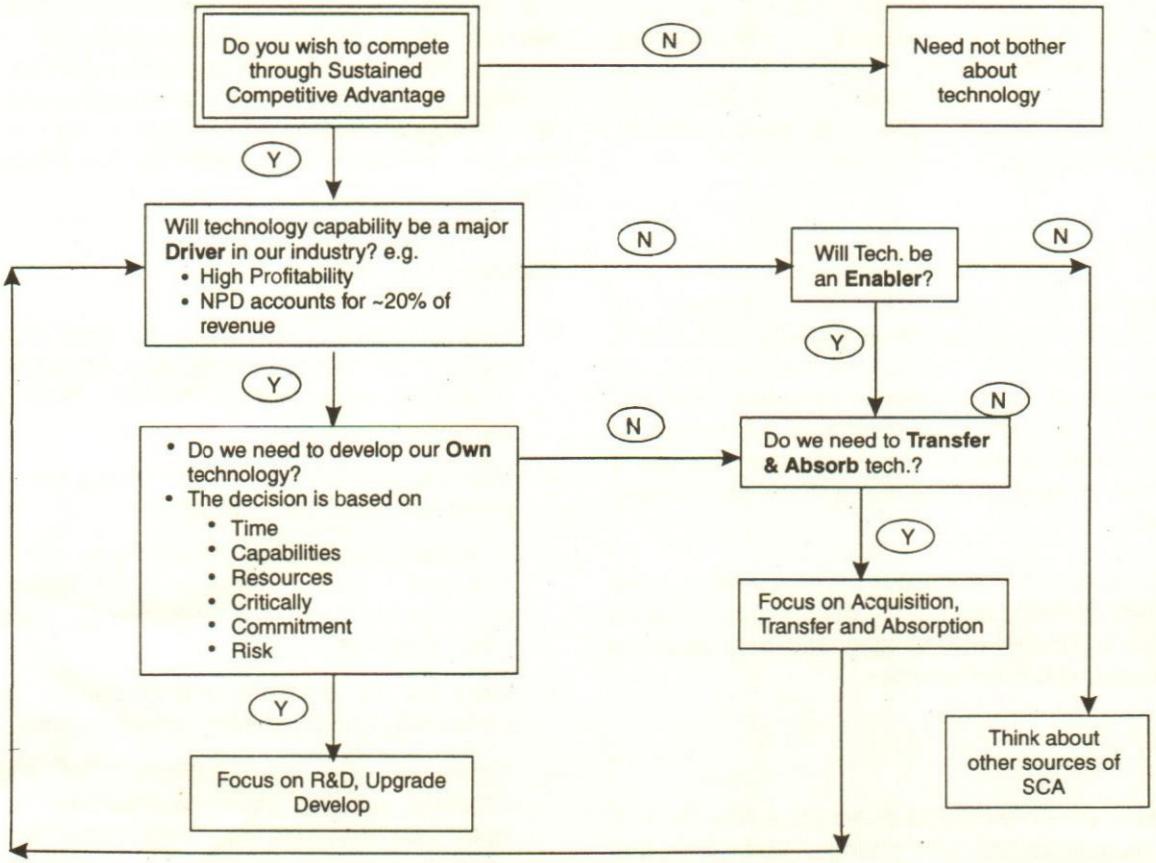

Fig. 3. Decision Making Processes for Technology Capability Building within firms: A Conceptual Framework
Y = Yes, N = No; SCA = Sustained Competitive Advantage

information management and coordination of capabilities. The national technology capability can be termed as sum of technological capabilities of the country's firms. Technology capability building is 'the ability of organisations to handle technologies and cope up with technological changes' or 'abilities of organisation which enable it to undertake various technology activities'.

Innovation

In simple management terms, innovation is a new product or service that is successful in the marketplace. Among many typologies of different type of innovations, some are listed as (a) the degree of technology management capability required to successfully perform them; and (b) their impact on an enterprise's sustainable competitiveness. Broader definitions of innovations, often discussed are management innovation, incorporate important dimensions of market/customer innovation and operational innovation in addition to innovation of technology / product / service (Fukushima, 1999). At the higher level one has to consider national/international and societal innovations. For instance, European Union (EU) has taken up a number of initiatives to strengthen innovation systems in member states through interventions such as innovation relay centres. The focus of this paper is technological innovation.

Competitiveness

Competitiveness is a very useful yet complex subject and encompasses different issues developing on levels: country, industry, firm, product and technology. Detailed definitions at different levels including measurement variables have been synthesized through an extensive literature review by Banwet et al. (2002). Here a simple definition of competitiveness at the firm level is adapted from Momaya (2001). Competitiveness of a firm is the ability to undertake any or all activities on the value chain from conceive, design, engineer, manufacture, market, finance to service of a product or service or a bundle of products and services, superior to those offered by competitors considering the price or non-price quality on a sustained basis.

In light of the above definition, technological competitiveness can be defined as the ability to

develop, transfer, absorb, productionise or commercialize technologies to support competitiveness. Detailed criteria has been identified in the book (Momaya, 2001) for technological competitiveness under each facet of competitiveness: Assets, Processes and Performance.

Capabilities

A capability is the capacity for a set of resources to integratively perform a task or an activity (Hitt, 2001). Through continued use, capabilities become stronger and more difficult for competitors to understand and imitate. As a source of competitive advantage, a capability should be neither so simple that it is highly imitable, nor so complex that it defies internal steering and control.

For instance, the knowledge possessed by the firm's human capital is among the most significant of an organization's capabilities and may ultimately be at the root of all competitive advantages.

Flexibility

Flexibility is a concept that demands agility and versatility. It is associated with change, innovation and novelty, coupled with robustness and resilience. It implies stability, sustainable competitive advantage and capabilities that may evolve over time (Sushil, 2001).

Problem Structure

The problem of weak technological capabilities in developing countries is quite complex and needs systematic exploration. Using problem-structuring technique, we have tried to structure the problem and identify the root causes for weak technological capabilities with focus on the firm level. Hence, most components of the problem structure – Goals blocked, reasons, constraints and ambiguities are developed at the firm level only. The structure is developed based on extensive literature review as well as idea generation exercises to synthesize and prioritize ideas of team and ones that emerged from questionnaire survey of professionals. Given below (Fig. 2) is a glimpse of the generic picture, beginning from general symptoms at the country level to more specific symptoms at the firm level. Detailed problem structure is given in Annexure I.

Issues and Key Questions

Detailed and factual problem structuring provides a great sounding board to evolve key issues or questions that should be considered if India is to address the problem of slow technological capability building. Prioritized list of key issues or questions on technology, technology capabilities and technology capability building for competitiveness is classified at the country and firm level and given below with important issues listed first:

Country Level Issues

- Why is India's performance so poor on available global indicators of technology despite the claim of having the second largest pool of scientific/ technical human resource?
- Can the performance on the global indicators address real problems of India?
- Is building technology capability at firm/organization level a good strategy to build overall technology capabilities or competencies of the country? Why / Why not?
- What are the problems and challenges in India in technology and innovation management?
- What are the best indicators of technology capability building? How will they differ across different industries and in different stages of the firm?
- What has been the technological and competitiveness performance of India and her firms as per indicators? As per World / Global reports? What are the reasons?
- What are the best practices in India and a technologically developed country such as Japan? What are the major differences?
- What are the root causes of technology leadership of countries such as USA/ Japan?
- How can India become technologically better, through learning from collaborations with technology leaders?

Firm Level Issues

- What concepts/ frameworks can help in improving technological performance and linking it to competitive performance?
- What are the values that should guide key decisions in building technology capability?
- How can Flexible Systems Management be used for Technology/Innovation Capability Building?
- What are the best ways to equip managers with knowledge, tools, processes of technology / innovation management?

- Is the role of technology and innovation management very different in different industries? For which types of industries is it more important?
- Does the use of any systematic framework/ models aid massively in technology/ innovation management? Which ones?
- How can the role of technology/ innovation in enhancing competitiveness of an organization be quickly evaluated?
- What are the key learning of technology capability building from a decade of liberalization?
- Informal sector is a very large part of the Indian economy. Chandra (2003) attributed 93 per cent of total employment and 60 per cent of wealth creation to the sector. Unfortunately the productivity of the sector is very low (gap between formal and informal sectors is 16 times). How can technology capabilities be used to improve productivity as the implications for the economy are enormous.
- Will technology and capabilities really reduce, divide or add another divide of knowledge-workers and non-knowledge workers in the emerging knowledge era?
- What are the key implications, suggestions from learning?

Findings and Implications

The study gave an opportunity to explore and find out real problems and challenges for technology capability and its processes for firms in India. Feedback from a total of 67 professionals through questionnaire surveys were received. These respondents were from industry, government and academia, mostly in the National Capital Region of Delhi. These were people with more than five years, on an average, experience. Very senior industry experts were also there and their response have been considered with higher weighs. Five case studies were also developed for detailed probing. Most of the data for these firms were takes from secondary sources. These firms were research-based firms. A glimpse of the findings from the study is summarized below.

- Most firms or organizations evaluated in detail during research are small and have poor understanding of formal processes to evaluate competitiveness or technological competitiveness.
- Most firms are at early stage of evolution, so it is difficult to comment on their competitiveness. However, preliminary evaluations reveal that they have a very long way to go to becoming leading world-class technology firms.
- Technological capabilities may be there in some firms, but most firms are not able to demonstrate formal processes.
- Such lack of formal processes may be a reason for slow improvements in technology capability building.

There are many implications of the low technology capability building and related processes on the competitiveness of firms in India. Despite significant achievements in select technological fields such as space, missiles and software, the technological capabilities of an average Indian firm, organization, household and individuals remains far below international benchmarks. Poor technological capability is often a barrier and the main reason for such poor performance. The low level of appreciation for technology and innovation has made the firms take a defensive posture. After following the follower strategy in technology management for decades, it is difficult to change the mindset and actions of most of the leaders and firms. In India, significant spending on research is done by government / public sector, which mostly focus on basic research. The private sector invests in areas where commercial application of technology is possible. Major global firms are setting up their offices in India to take advantage of the quality and relatively low cost of scientific human resources for research in their firms, but Indian firms have been slow at leveraging these human resources for years.

Means of Developing Technological Capabilities in Indian Firms

Firms that wish to lead in value creation will have to make major changes in their strategies and implement them successfully. Many successful firms have already surged miles ahead. A conceptual framework for key decisions about technological capabilities for firms was developed by synthesizing learning from research (Fig. 2). The firms need to strengthen their processes to know the evolving role of technology, innovation and knowledge for competitive advantage. Such development needs enormous learning for the organization, teams and individuals. Firms should support learning efforts by their managers in such subjects through long-term, such as MBA, or short-term management development programmes. Many quality programmes are available at leading institutes in India.

Firms that decide to develop their own technology need to build technological capabilities systematically. The decision involves issues of commitment, confidence, risk, resources, time and capabilities. The actual process is likely to evolve over years, although key

decisions may be taken in a few months or even weeks. Most important task concerns creating a shared vision and committemnt to building technological capabilities. Once this difficult task is accomplished, other tasks of organizing resources, most challenges being human resources, creating environments and sustaining journey are achievable. However, if the risk, time or other constraints do not permit focus on indigenous development, firms should strengthen their ability for rapid technology transfer and absorption for achieving goals of competitive advantage through technological capabilities. Select ideas that can help in building technological capabilities are listed below:

- Innovative learning for all stakeholders, to begin with top most leadership about awakening, importance, application of technological capabilities for SCA.
- Forming multidisciplinary teams to evolve long term projects about Technology, Technology Management and Technology Capability Building.
- Identify most appropriate processes of TCB relevant for team, division, SBU & Firm.
- Through an assessment of the potential for making an industry internationally competitive and sustaining competitiveness through unique capabilities of clusters and other advantages.
- Create high commitment across the industry to innovation, Kaizen and learning.
- Develop right perspectives, skills that encourage indigenous technologies through interventions.

Conclusions

India has many achievements, yet she has been slow at improving the quality of life for its masses. Low and very slowly improving competitiveness amply reflects slow progress of India on key fronts such as development, trade and technology. Sustained competitiveness through technology demands building technological capabilities. Despite good intentions and goals, India and her firms have made very slow progress on building and leveraging technological capabilities for the local or global masses. India lags behinds when compared with developed or even emerging countries on macro-economic indicators of technology, technology management and technological capability. An attempt has been made to synthesize knowledge from diverse sources to draw a picture of problems and their root causes in this paper. While some root causes such as mismatch in attitudes, culture, scientific spirit and environment may be attributed to country level, large number of important causes at the firm level hints at enormous scope for improvement. This is more important in an emerging era where firms in India are expected to play a much more proactive role in technological and overall competitiveness.

The firms in India need to improve their competitiveness to survive and succeed. There may be many challenges and problems related to the technology capability building in firms in India, which is evident from the problem structuring based on primary and secondary data analysis. There is also an urgent need to develop, experiment, refine and disseminate knowledge about simple yet effective indicators of technological capability that can aid quick evaluations and action.

Acknowledgement

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Annexure I

Problem structuring technique was used to get a detailed picture of the problem at important levels.

Unwanted Symptoms

Country level

- Unsatisfactory / very slowly improving quality of life in many parts of the country (Mashelkar, 2001)
- Slow and unbalanced economic progress
- Inadequate opportunities for talent within the country (as reflected in symptoms such as brain drain)
- Low global market share and negligible share in technology markets
- Low leverage of science and technology to solve problems or create opportunities
- Slow formation/upgrading /weak technological clusters
- Low and slowly improving productivity in many sectors (including emerging sectors such as IT)
- Inadequate linkages between industry and academia (Ramamurthy, 2003)
- Outdated technologies in many sectors / firms
- Acute shortage of intelligent skilled workers (not scientists and engineers) (Ramamurthy, 2003)
- High functional illiteracy, poor skills (not adequate for emerging knowledge economy)
- Lack of investment in developing technology comparable to international standards (Bala, 2003)
- Very slow growth of high–end skill formation resulting in stagnating job opportunities

Firm level

Efforts were made to identify symptoms taking average firms in India as target sample. Many exceptions may exist in India that have income over many countries and such symptoms are things of the past or never happened

- Very few companies have reached global ranks such as Fortune
- Most Indian firms have low / stagnant / declining global market share
- Persistent technology trade deficit (gap between technology exports – imports)
- Loose fit between Technology/R&D and marketing/other departments
- Inadequate benefits drawn from improvement over acquired technology (Indiresan, 2003)
- Indian firms rarely rank anywhere (top or even bottom) in technological lists such as top patent-holders
- Repeated import of same technology; unable to

absorb technology rapidly

- Many large firms are destroying value; a survey reported that almost 80 % of top 500 destroyed value
- Many small firms are struggling for survival; in fact many have closed shop
- Not able to improve cost / benefit for technologies
- Low importance given to technology/innovation management, just imitator strategy?

Goals Blocked

Desirable goals that the firms should pursue are listed. We have identified goals in positive terms, as very rarely an organization pursues negative goals explicitly.

- Create economic value
- Contribute to the economy and society in terms of opportunity creation (e.g. employment)
- Satisfy customer needs through quality goods and services
- Contribute to global needs
- Become world-class players
- Have a portfolio of world class products/ services/ technologies for future
- Have high total factor productivity

Reasons for Unwanted Symptoms or Goals Blocked

This is the most important component of problem structure. The root causes were identified by using techniques such as "why-why". Hence, real root causes might have emerged deep in the following list:

- Unfavourable environmental factors: Macro/ Micro
- Late and less effective market liberalization
- Less rigorous and coherent efforts by all stakeholders (Bhat, 2001)
- Less experience in handling large and complex projects
- Inability to manage the technology capabilities building process over long horizon (e.g. decade) (Madanmohan, 2000)
- Lack of use of appropriate technology and appropriate *places* (Indiresan, 2003)
- Low use of locally developed technology innovations; preference to imports (AIMA, 1997)
- Low techno-managerial capabilities
- Low ability in attracting capable human resources in technology management
- Inadequate recognition of technological talent *and their work/ achievements*
- Not knowing the technology, hence often installing technology for wrong reasons (e.g. technology push)
- Low rate of knowledge creation; few firms have experimented with new perspectives on the theory of the firm – A firm as a Knowledge-creating Entity (Nonaka, et al, 2000)
- Low desire and capabilities to convert knowledge into business (the scientific community is happy with generation of knowledge and does not think of converting knowledge into business) (Ramamurthy, 2003)
- Attitude for *know whats; neglecting know hows* and *whys*
- Few audits of opportunity costs or profits lost due to "risks not taken" (Indiresan, 2003)
- Innovation is not an appreciated and encouraged thing and only few firms are able to initiate radical or breakthrough innovation (by global benchmarks)
- Poor complimentary assets such as finance, high–end skills and competencies
- Limited implementation/ execution capability
- Weak leverage of technology for competitiveness
- Poor understanding of the "why of competitiveness" (Hamel and Prahalad, 1996)
- Top management in many firms have narrow and short term horizons
- Low aspirations/ poor attitude and confidence (as often mentioned by management gurus with global experiences such as Prof. Prahalad)
- Lack of scientific spirit and intellectual culture (Indiresan, 2003)

Constraints

- Weak real technology culture (Indiresan, 2003)

- Slow improvement in an organization that encourage excellence and few self motivation professionals
- Low and stagnant competitiveness of the country
- Less ability to cope with diversity
- Unclear policy / lack focus area
- Complex process of management of innovation, R&D and creativity (Bhat, 2001)

Ambiguities

Poor understanding of ambiguities about the problem and its real dimensions can often be the root cause of the inability to address real problems. Knowing what we don't know is very tough, but a small attempt has been made to identify such ambiguities.

- Whether technology and innovation management gives a competitive edge? In what industries/segments?
- How is the performance of Indian firms in terms of commercialization of technology investments? What are the strategic and operational reasons?
- Are many firms in India ready for knowledge-driven innovation?
- Can India afford to spend/ invest more on R&D without being sure of the effectiveness and efficiency of technology capability building processes for commercialization / competitiveness / business results?
- Can we manage technology/knowledge/innovation, if foundations remain weak?
- Can we build superb technological and other capabilities without addressing basic problems / root causes such as weak teamwork, commitment and ownership?
- How can we overcome such basic problems?
- Is technological competitiveness of India really low or it is just less visible?
- India is often projected as a base for R&D (e.g. MNCs in Software, IT). How well has this helped build local technological capabilities (e.g. in software firms in India)? □

The immature mind hops from one thing to another; the mature mind seeks to follow through.

– Harry A. Overstreet

Feature

Vehicle Routing in Supply Chain Management

S. Balan, P. Asokan & Pradeep Kumar

This paper provides guidance for the managers to actually plan their distribution strategies of how to ship finished goods from production centres to warehouses in a timely and cost efficient manner. A traditional and a nontraditional heuristic algorithm have been deployed to optimize the distance travelled by the vehicle in the vehicle routing model. The algorithms used are heuristic and hence do not provide the optimal solution but close to the optimum. This model is applied to a dairy industry that has the largest network in India, based at Trichy.

S. Balan is Research Scholar, Department of Mechanical & Industrial Engineering, Indian Institute of Technology, Roorkee. P. Asokan is Assistant Professor, Production Engineering Department, National Institute of Technology, Trichy-15, India. Pradeep Kumar is Professor, Department of Mechanical & Industrial Engineering, Indian Institute of Technology, Roorkee.

In today's era of globalization and cutthroat competition, customer satisfaction has become an issue of prime concern and that is where the role of Supply Chain Management (SCM) comes in, which actually emphasizes on the concept of a virtual chain linking the suppliers, manufacturers, distribution channels and customers, not as individual entities but as one single organization of pooled resources and skills. In order to gain a competitive edge, it is essential to satisfy those demanding customers who insist on personalized products being available on time yet at a minimum cost. The need is to shorten product life cycles but at minimum costs and SCM is one such tool, which has been successfully used.

Figure1 shows two types of supply chain, a simple chain and a complex supply chain applicable to the real world cases. Logistics (which is basically the science of movement of materials, intermediaries and final products from the producer to customer) costs constitute a major portion of the total costs in a supply chain and, hence, constant efforts are required to minimize the cost (Vijayaraghvan, 1999). Literatures has revealed how important is the concept of logistics in supply chain management and how critical is the role of transportation in logistical management (Beltrami E.J. and Bodin L.D, 1974). In India the total logistics costs constitute nearly 10% of the CNP out of which 40% is due to transportation alone (Pari Venkat and S.Thiruvenkitaswamy,1999). Transportation plays an important role in logistics and hence it is a critical subfunction (Kale V and R.V. Kulkarni, 1999). But essential element of any logistics system is the allocation and routing of vehicles for the purpose of collection and delivery of goods and services on a regular basis. Common examples of vehicle routing include newspaper delivery, milk distribution, school bus routing, municipal waste collection, fuel oil delivery and truck dispatching in a number of industry. The system may involve a single depot or multiple depots. The number of routes is considered as the primary objective and for the same

number of routes; the secondary objective is to minimize the total travelled distance. Constraints may be imposed upon the:

- depots (numbers, possible locations, and production capabilities),
- vehicle fleet (type and numbers of vehicles, and their capabilities),
- delivery points (demand requirements etc),
- routing structure (maximum time and distance limits etc) and
- system dynamics (inventory holdings etc).

The problem, thus, seems to involve the design of several vehicle tours to meet a given set of requirements for customers with known locations, subjected to the above constraints. The main focus of the project is to generate all these solutions and hence serve as a Decision Support System (DSS) by solving the problem both for local optimal and global optimal algorithms and to meet the objective of vehicle routing problems. Now with IT (Information Technology) acting as an enabler, it has become much easier to actually utilize such optimization models, databases, etc. and establish an effective decision support system, which can help the managers in better and efficient decision-making. This work focuses on the distribution end of the supply chain, i.e. the outbound logistics. It describes heuristic algorithms for efficient vehicle routing and a comparison based study using a computer package, which again helps in decision-making. A typical vehicle routing problem can be described as a problem of designing least cost routes from one depot to a set of geographically scattered points (cities, stores, warehouses, schools, customers etc). The routes must be designed in such a way that each point is visited only once by exactly one vehicle, all routes start and end at the depot, and the total demands of all points on one particular route must not exceed the capacity of the vehicle.

Mathematical model

Out of many existing heuristics for vehicle routing, a few common ones reselected to be incorporated in the DSS are Tyagi's algorithm, Gillet & Miller's sweep algorithm, Tabu Search algorithm, Simulated Annealing and Genetic Algorithm.

Tyagi's algorithm

Let $p_1, p_2,...,p_n$ be the delivery points with $q_1, q_2,...,q_n$ as the demands respectively, to be serviced from a central depot p_0. All inter distances d_{ij} (i,j = 0,1,...,n) between the points are given and assumed to be symmetric (Tyagi, 1968). There are a large number of trucks available, and for the present case it is assumed to be of a given capacity 'c'. If the capacity of the truck satisfies then

$$c \geq \sum_{i=1}^{m} q_i$$

The problem is the same as the Traveling Salesman Problem. It is assumed in the present case that capacity of the carrier satisfies the following relation:

$$c << \sum_{i=1}^{m} q_i$$

Mathematically the truck-dispatching problem may be stated as follows:

- A set of n points p_i, (i = 1, 2...n) to which deliveries are made from a point p_0, called the central depot.
- A symmetric matrix d = d_{ij} called the distance matrix which gives the distance d_{ij} between every pair of points (i = 1,2...n)
- The demand is q (i = 1, 2...n) of each retailer at the points p_i (i = 1,2...n).
- The capacity 'c' of the carrier available can be related as following:

$$c > \max (q_1) \text{ where } i = 1,2.....n$$

$$c << \sum_{i=1}^{m} q_i$$

If $x_{ij} = X_{ij} = 1$ is interpreted to mean that positions p_i and P_j are adjacent in any of the tour, then obviously

$$\sum_{j=0}^{n} x_{ij} = \sum_{j=0}^{n} X_{ij} = 1$$

The problem is to find those values of X_{ij}, which minimizes the total distance T

$$T = \sum_{i,j=0}^{n} d_{ij} * X_{ij} \text{ Subject to the conditions}$$

(i) Finding the number of trips required: This number depends upon the capacity of the carrier and the total delivery, which is to be made for a given problem. Thus, the number of the trips is given by

$$N = \left\{ \sum_{i=1}^{m} q_i \right\} / c, \text{ if c is a perfect divisor of } \sum_{i=0}^{m} q_i$$

= No + 1; otherwise

Where No denotes the greatest integer portion of $N = \left\{\sum_{i=1}^{m} q_i\right\}/c$

(ii) Grouping of the delivery points: The delivery points P_i (i =I, 2..... n) are then divided into N groups. The number of points in each group may differ according to demands. Start at the distribution center and go to the nearest retailer point. Keep doing this until the demand sum is below the capacity of the truck. Arrange all the demand points in one group. Once a truck capacity is fully delivered start the other group.

(iii) Finding the optimal tours: Having grouped delivery points, as G_1, G_2....., G_n the truck dispatching may now be thought of as solving n symmetric TSPs.

Gillett's Algorithm or Sweep Algorithm

The algorithm discussed (Gillet and Miller, 1974) often yields an optimum or near optimum solution to the single depot Vehicle Routing (VR) problem. The following notation and definitions are used to formulate the algorithm:

N	:	no. of locations including the depot {depot is always location 1}
Q (i)	:	demand at location i
(x(i), y(i))	:	rectangular co-ordinates of location i
C	:	capacity of each vehicle
D	:	maximum distance each vehicle can travel
A (i,j)	:	distance between locations i and j
An (i)	:	polar co-ordinate angle of location i, defined as An (i) = arctan [(y(i)-y(l)/(x(i)-x(l))]
R (i)	:	radius from location 1 to location i.

The constraints can be formulated as:

Q(i) ⇐ C, for all i

A(ij) > 0 , for all i,j

A(i,i) = 0

A(i,1) + A(1,i) ⇐ D, for all i. Locations are numbered according to the size of their polar co-ordinate angle. If there exists an i and j such that An(i) = An(j), then i <j, ifA(i,l) A(l,i). This determines a unique ordering.

Tabu Search Algorithm

The idea behind Tabu Search (TS) is again to modify the local search in order to escape from local minima (Kulkarni and Kale, 1998). In the TS case this is accomplished by moving onto the best solution of the neighborhood at each iteration, even though it is worse than the current one. A special memory structure called Tabu List (TL) forbids returning to already explored solutions. The general structure of the TS algorithm is as follows.

1. Generate an initial feasible solution S, set S' = S and initialize TL = Ø.

2. Find S', such that $\dot{S} \in N(S)$ and $Z(\dot{S}), \forall \hat{S} = \min \{z(\hat{S}), \forall \hat{S} \subset N(S), \hat{S} \notin TL\}$.

3. S = S', TL = TL ∪ S, if (z(S') > z(s)) set S' = S.

4. If not (end condition) go to step 2.

In the case of TS the intensification and diversification strategy must be explicitly implemented with reference to the actual memory structures used to store the Tabu list.

Simulated Annealing Algorithm

The simulated annealing method resembles the cooling process of molten metals through annealing (Alfa et al, 1999). At high temperature, the atom in the molten metal can move freely with respect to each other but as the temperature is reduced, the movement of the atoms gets restricted. The atoms start to get ordered and finally form a crystal having the minimum possible energy. However, the formation of the crystal mostly depends on the cooling rate. If the temperature is reduced at a very fast rate, the crystalline state may not be achieved at all, instead, the system may end up in a polycrystalline state which may have a higher energy state than the crystalline state. Therefore, in order to achieve the absolute minimum energy state, the temperature needs to be reduced at a slow rate. The process of slow cooling is known as annealing in metallurgical idiom. The algorithm is as follows,

1. Choose an initial point $x^{(0)}$, a termination criterion ε. Set T a sufficiently high value, number of iterations to be performed at a particular temperature n, and set t=0.

2. Calculate a neighbouring point $x^{(t+1)} = N(x^{(t)})$. Usually, a random point in the neighbourhood is created.

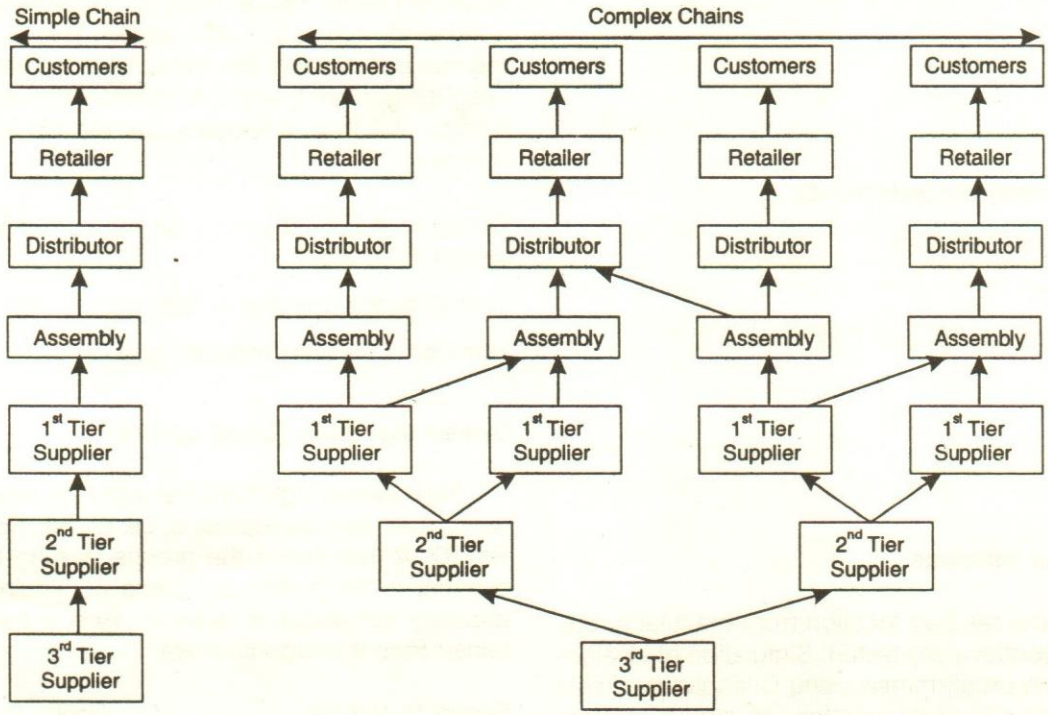

Fig. 1. Two types of supply chains

3. If $\Delta E = E(x^{(t+1)}) - E(x^{(t)})$ (<) 0, set t = t + 1; else create a random number (r) in the range (0,1). If r ⇐ exp (-ΔE/T) set t = t + 1; else go to step 2;

4. If $| x(t+1) - x(t) | < \varepsilon$ and T is small, Terminate; else if (t mod n) = 0 then lower T according to a cooling schedule. Go to step 2.

Genetic Algorithm

Recently, Genetic Algorithms (GA) have received considérable attention regarding its potential as an optimization technique for complex problems and has been successfully applied in the area of industrial engineering. The well-known applications include scheduling and sequencing, reliability design, vehicle routing and scheduling, group technology, facility layout and location, transportation and many others (Mitsuo Gen and Runwei Cheng, 1999). Population based search and meta-heuristics are the two salient features of GA. The so-called Roulette Wheel selection method has been deployed here to select the initial chromosome. Cross over and mutations are the two vital operations carried out in GA. It operates on two chromosomes at a time and generates offspring by combining both chromosomes features. A typical crossover process is shown in Fig. 2 and in this a random cut-point is chosen and the offspring is selected by combining the segment of one parent to the left of the cut-point with the segment of the other parent to the right of the cut-point.

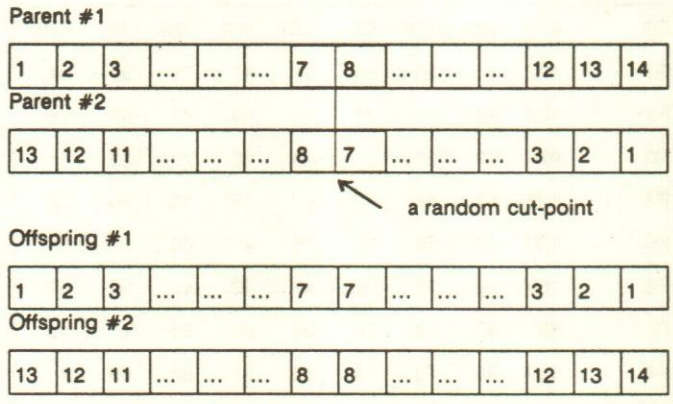

Fig. 2. Cross-over Process

This method works well with the bit string representation. The crossover rate (denoted by P_c) is defined as the ratio of the number of offspring produced in each generation to the population size (usually denoted by pop size). This ratio controls the expected number P_c x pop size of chromosomes to undergo the crossover operation. A higher crossover rate allows exploration of more of the solution space and reduces the chances of settling for a false optimum; but if this rate is too high, it results in the wastage of a lot of computation time in exploring unpromising regions of the solution space. The mutation rate (denoted by P_m) is defined as the percentage of the total number of genes in the population. The mutation rate controls the rate at which new genes are introduced into the population for trial.

Begin

f ← 0;

initialize P(t);

evaluate P(t);

while (not termination condition) do

recombine P(t) to yield C(t);

evaluate C(t);

select P(t + 1) from P(t) and C(t);

t ← t+l;

end

end

Design of User Interface

By giving the retailers location from manufacturers, the various algorithms are tested. Simulation of all algorithms has been programmed using C language. Table 1 represents the real world locations of various retailers associated with the manufacturers. For convenience only 8 retailers are taken here and the software will support more than 100 retail outlets. In all the algorithms each group represents the vehicles to be routed. The above example is solved by using the local and global optimal heuristic algorithms (Assume capacity of vehicle = 8).

Table 1: Retailer information matrix

Distance	R0	R1	R2	R3	R4	R5	R6	R7	R8
R0	x	122	102	97	123	130	168	85	129
R1	122	x	29	59	61	47	79	90	94
R2	102	29	x	31	44	35	75	62	75
R3	97	59	31	x	30	36	72	32	44
R4	123	61	44	30	x	16	41	55	35
R5	130	47	35	36	16	x	40	65	51
R6	168	79	75	72	41	40	x	95	62
R7	85	90	62	32	55	65	95	x	45
R8	129	94	72	44	35	51	62	45	x
Demands		3	2	2	4	3	1	2	2
Angular Position	2	12	30	30	22	26	50	46	

Tyagi's method (local optima)

Tyagi's method is based on the concept of the nearest neighbour. Using this algorithm the closest retailer from R0 is found to be R7, with a demand of 2. Now the nearest retailer from R7 happens to be R3, with a demand of 2, and is also added. This is continued till the number exceeds the capacity of the vehicle. Hence, Tyagi's algorithm groups the retailers first into respective groups and then schedules the retailers in each group by using TSP.

Group 1: 0-7-4-3-0 Group 2: 0-2-5-1-0
Group 3: 0-8-6-0

Total distance travelled = 926 units

Number of vehicles required is: 3

Sweep algorithm (Local optima)

Now sweep algorithm first sorts the retailers according to their angular locations, i.e. RI, R2, R5, R6, R3, R4, R8, R7. It then forms the groups starting from the first element in the sorted array and continuing unless the capacity constraint is violated. Hence the results obtained from this algorithm are:

Group 1: 0-2-1-0 Group 2: 0-3-6-5-0

Group 3: 0-4-8-0 Group 4: 0-7-0

Total distance travelled = 1134 units
Number of vehicles required is: 4

Tabu Search algorithm (Local optima)

This algorithm gives the solution shown here. The numbers of iterations are given as 10 and the initial route has been selected as, 0-3-2-4-5-7-8-6-1-0. After 10 iterations the shortest distance obtained here is 530.000000 units and the corresponding number of vehicles required are 3.

Group 1: 0-3-2-4-0 Group 2: 0-5-7-8-6-0

Group 3: 0-1-0

Simulated annealing algorithm (Global optima)

Required input parameters are, Initial temperature (^{o}c): 480, Cooling Rate: 85% and the selected random initial solution: 0-2- 6- 1- 7- 5- 3- 8- 4 -0. After feeding all input the output at the end of 10^{th} iteration is, the solution is accepted with a probability of 0.858207.

The final temperature is (^{o}c): 94.499718. The optimal route: 0-2- 6- 1- 7- 5- 3- 4- 8-0.

The fitness value (total distance travelled): 557 units

Group 1: 0-1-7-2-6-0 Group 2: 0-3-5-0

Group 3: 0-4-8-0 Number of vehicles: 3

Genetic algorithm (Global optima)

The parameters required are, population size: 10, the number of genes: 8. The generated initial chromosomes are:

6 4 1 2 5 7 3 8	2 4 6 7 8 5 3 1
8 2 3 7 5 4 1 6	8 7 1 3 4 2 6 5
3 8 2 5 4 7 1 6	1 4 8 6 2 7 5 3
7 8 3 5 1 4 6 2	1 4 8 3 7 6 5 2
4 5 8 6 1 7 3 2	8 4 5 6 3 7 2 1

After giving the crossover probability and mutation probability at the end of the tenth iteration the optimum value obtained here is,

The number of vehicles is: 3, the corresponding route is: 0-8- 6- 5- 4- 2- 1- 3- 7-0

Group 1: 0-8-6-5-0 Group 2: 0-4-2-0

Group 3: 0-1-3-7-0

The fitness value (total distance travelled): 919 units

Uncertainty analysis

For the Vehicle Routing model the following uncertainties may often arise,

- Addition of new retailers, leaving one or more retailers or retailers changing their locations
- Change in demands of the retailers etc.,
- Changes in route because of traffic jam etc.,
- Breakdown of the vehicle

Discussion of results

The vehicle routing programme will be very helpful to the management is deciding the correct routing of the vehicles from the warehouses to the retailers (Golden, and Magnanti, 1977). Moreover, it will also provide multiple alternatives to the management for routing their vehicles, due to the different heuristic methods used, and thus, it can select the one which it finds most appropriate. The retailer-retailer distances, their demands and approximate angular locations have been tested; the programme has been executed for different values of demand of retailers and the results have been compared graphically (Graph.1). Among all the developed methods, Genetic Algorithm method yielded the best results for most of the cases when the capacity of the truck was taken to be very large as compared to the average demand of a retailer, around 20-30 times, closely followed by the developed simulated annealing. However, the developed algorithm yields better results when the capacity is around 2-3 times the average demand. For the given input data, Tabu Search model gave the best results till the capacity of the vehicle was greater than 8. The sweep algorithm can prove to be a helpful tool when the retailers are in a more or less circular pattern, i.e. approximately on a common circumference. Genetic Algorithm will be a better option for the user because of its global optimal solution at the stage of 70^{th} iterations.

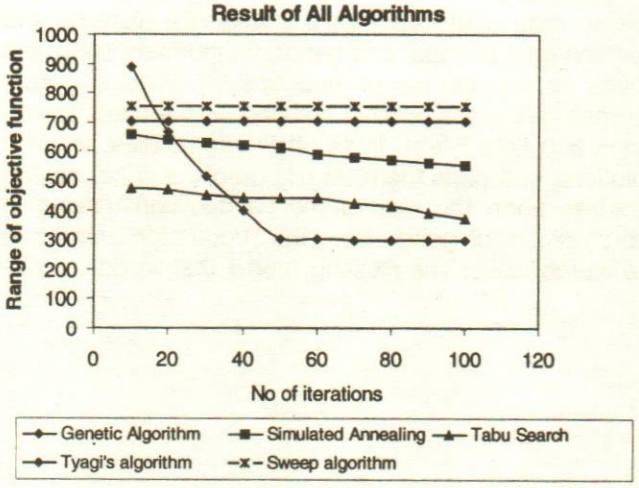

Fig. 3. Objective function Vs Iterations

Case study

ABC Milk is a large industry with around 8.0 lakh litres of milk shipped daily from their central depot (Trichy) to different parts of India. They have more than 1500 retailers in Tamil Nadu alone and about 300 insulated carrier vehicles to do the job. Feeding the entire data in the database is a tedious job. Hence, small segments near Trichy were chosen for the DSS on 40 retailers. The Vehicle routing model was applied to the data from ABC Milk. The data given was not very accurate and also incomplete; hence, a few approximations were made, regarding the locations of the retailers and their demands. The retailers selected were mainly from the Thiruvarumbur area and parts of Balpannai and Kattur (Trichy province). Besides, in a real life situation it is very difficult to claim that the solution given by this DSS will always be the best due to the numerous real time constraints that come into play. The alternative modes of transport available, the traffic on the roads,

breakdown of vehicle(s), seasonal fluctuation in tile demand of the item (e.g. milk), difficulty in calculation of the exact times of transportation and angular locations of retailers, etc. are some of the few factors that can affect the efficiency of the optimal solution generated by the DSS. But nevertheless this DSS works as an efficient tool to help managers take some key decisions regarding their mode of distribution management.

Conclusion

Inadequate transport facilities, lack of well developed road and rail networks, poor quality roads and maintenance levels, etc., constitute major infrastructure bottlenecks in efficient logistics and hence, it necessitates concentration in these areas. To illustrate the application of this model a simple example was solved using all the algorithms. It takes the distance and demand data as input and generates numerous efficient points on the number of iterations Vs distance graph. Besides giving the optimal solution with respect to distance and time it also finds other intermediate efficient solutions and plots them on the graph, and hence, improvises upon the management's decision making in the shipment of goods from the production centres to the warehouses. The existing model that works on distances can be easily modified and converted to minimize the cost of transportation by giving weights to the various paths between the retailers, but these weights have to be decided depending upon the nature of the existing paths, e.g. the traffic on the roads, condition of the roads, available mode of transport, etc.

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One of the hardest tasks of leadership is understanding that you are not what you are, but what you're perceived to be by others.

– Edward L. Flom

Feature

JIT in the Service Sector

Anil Gupta, Raj Kumar & Dixit Garg

Just-in-Time (JIT) concepts have been successfully implemented in manufacturing organizations. There is reasonable consensus among researchers that JIT is a useful and beneficial approach reducing manufacturing costs while simultaneously improving the quality of a product. However, all reported instances of successful and unsuccessful JIT practices lie mainly within manufacturing settings. These JIT concepts and tools, originally developed in the manufacturing domain, can be identified, analyzed and altered to fit and benefit service organizations. This paper critically examines the potential of JIT within the Indian Service Sector. An analysis of a questionnaire supplied to various service industries is carried out with the help of statistical tests. The paper identifies existing problems and benefits that can be achieved by implementing JIT in Indian service industries. Some research directions have also been identified.

Anil Gupta & Raj Kumar are with the Mechanical Engineering Department, C.R.State College of Engineering, Murthal (Sonipat), Dixit Garg is with the Mechanical Engineering Department, National Institute of Technology, Kurukshetra, India.

It is perceived by many that service industries operate in a different manner compared to manufacturing industries. However, it has been suggested that some concepts and tools developed in the manufacturing domain can be altered to fit and benefit service organizations. Manufacturing style of thinking should be applied to services which are people intensive. Highly automated and controlled conditions must be generated in providing services like an assembly line of a car manufacturing company. Behra and Chase [1993] have adapted the concept of Quality Function Deployment (QFD) for service firms. Statistical Process Control (SPC), Apte and Reynolds [1995], Concurrent engineering (CE), Yassine [1999], and quality circles all originated in manufacturing and then were adopted in service organizations, (Fitzsimmons and Fitzsimmons, 1994). This paper is built on the premise that the service sector can also benefit from JIT concepts.

The Just-in-time Concept

The basic idea of JIT was developed in Japan in the 1950s and subsequently achieved considerable success at Toyota Motor Company. JIT can be defined as a planning concept designed to eliminate waste. Waste is defined as anything other than the minimum amount of equipment, materials, parts, space, and workers' time, which are absolutely essential to add value to the product or service.

According to Schonerberger [1982], the JIT concept appears to be at the core of Japanese productivity improvements. JIT aims at avoiding production of parts before they are needed. JIT is accomplished by providing or delivering parts frequently in small quantities, ideally piece for piece (Schonerberger, 1982]. Not only do JIT methods reduce inventory-carrying costs, they also lower scrap and improve quality. Employees or customers have fast feedback on defects as ideally the lot size is gradually reduced to one. It eliminates waste, streamlines operations, promotes fast changeovers and close supplier relations, and adjusts quickly to changes in demand. As a result, products and services can be

provided quickly, at less cost, and in more variety. Much of the emphasis of JIT comes from being close to the customer, close to the supplier, and close to the worker. Services have traditionally excelled in those areas.

When JIT is used in the context of services, the focus is mainly on the time needed to deliver the services. Examples of fast delivery services are Domino's Pizza, Federal express and Express mail. Service Environments with repetitive operations with high volumes and tangible items, such as mail, checks or bills, are expected to benefit more from application of JIT principles.

Services are much like manufacturing in the sense that both employ processes that add value to the basic inputs used to create the final product. JIT focuses on the process, not the product. It can therefore be applied (in theory) to any group of processes, whether manufacturing or service. The philosophy behind JIT is to continuously seek ways to make processes more efficient.

JIT focuses on the process, not the product.

Literature Review

In one of the few articles dealing with JIT in the service industry, Weiters [1984] illustrated that justifying JIT in service industry on the basis of inventory reduction alone should be unnecessary. There are other significant attributes like continuous improvement, attention to any barrier to smooth production, commitment to reduce the changeover time, to eliminate breakdown and defects, to abolish stockouts and lost materials, to minimize material handling, better service time for customers etc. which have a greater role to play in services.

Only a small number of service firms have applied JIT to their administrative functions so far, but it includes many firms which are known to be innovative (Lee, 1990). At Hewlett-Packard's direct marketing division, for example, the process improvement efforts that focused on applying JIT to service functions reduced the rate of overdue receivables from the second highest in the company to the second lowest. The division also improved the lead-time in its shipment operations from 48 to 24 hours. A similar application of JIT has helped the California Department of Motor Vehicles improve its vehicle registration process. Errors contained in millions of vehicle registrations filed by automobiles clubs tripled the time the DMV takes to process registrations. The DMV has initiated productivity improvement efforts which include finding the errors, locating where the errors originated, and working with the offices to reduce the errors. The immediate result of the project was to decrease the error rate by 61%.

Inman and Mehra [1991] conducted three different case studies in case of telecommunication services, internal maintenance and packaging services of a manufacturing industry to show the potential of JIT in service industries along with implementation strategy. A lot of benefits of improved communication, elimination of warehouses, reduced supplier base, improved vendor performance, improved forecasting, improved service, improved quality, lower prices, reduced paperwork, reduced backlogs, less traffic time, reduction in waiting time, reduction in errors and complaints etc. have been reported for all the three cases as a result of applications of JIT. They also presented the complete strategy of JIT implementation. They were of the view that JIT and JIT like methods are useful to service industries. Benson [1986] reported that diverse service organizations from bank cheque processing centres to hospital operating rooms are now applying JIT philosophy to the special problems of service production. It was hoped that service industries will continue to investigate the potential advantages of JIT and the list of successful case histories will include hotels, educational facilities and leisure establishments.

Diverse service organizations from bank cheque processing centres to hospital operating rooms are now applying JIT philosophy.

The positive impact of JIT on the health care industry, restaurant business, warehousing operations, customer service centres, mail-order operations is very well documented [Whitson, 1997; Sinohara, 1988; Savage-Moore, 1988; Conant, 1998].

JIT applications in administrative areas resulted in improved efficiency, costs, customer service etc. by reducing administrative lead time, order filling time, set up times on all types of administrative activities, reducing backlogs, space requirements, management delays, providing fast information flows and stress on quality etc. [Manske, 1988; Funk, 1989]

A case study of Consultancy and technology transfer wing (CTFW) of an educational institute for implementation of quality management and its tools

carried by Saurabh and Deshmukh [1999] highlighted the importance of quality initiatives in the service sector.

Critical analysis in JIT purchasing in the Indian context was carried by Dixit Garg et al. [1996] and results indicated the scope of JIT implementation in India is fair. Survey results of JIT purchasing analyzed statistically by Radovilsky et al. [1996] identified the leading predictors that strongly influence the results of JIT purchasing.

A survey of Indian service industries

A questionnaire on relevance of JIT in the Indian Service Sector was prepared and sent to 80 different Indian service industries. The questions in this survey inquired about different aspects of JIT applications in the Indian Service Sector. Forty-three responses (Response rate = 54%) to this questionnaire were obtained. Majority of these respondents are from North India because of logistical constraints. Out of the 43 companies surveyed; 4 are from the education sector; 6 from Banks; 5 from Hospitals, 5 from Maintenance, 15 from Manufacturing; 4 from consultancy; and 4 others.

Table 1: General profile of companies

Type of the service sector	Education (4), Banks (6), Hospitals (5), Maintenance (5), Manufacturing (15) Consultants (4), Others (4)
Annual turnover in crores	Maximum (9400), Minimum (1), Average (738.05), Median (300)
Number of employees	Maximum (20000), Minimum (8), Average (2215.26), Median (800)
Position of respondent	Top management (2), Upper middle level (15), Middle level (24), No response (2)
Awareness of JIT	Yes (38), No (5)
Benefits of JIT	very much (22), much (18), fair (2), little (1), not at all (0)
Use of JIT	very much (16), much (13), fair (8), little (5), not at all (1)
Scope of JIT Implementation in India	very much (20), much (16), fair (5), little (2), not at all (0)

The general profile of these service companies is tabulated in Table 1. Among respondents; 2 are from the top management level; 15 are from the upper middle level; 24 from the middle level; and 2 indicated no response. State of use of computer and information technologies (CIT) tools is presented in Table 2. The numbers in the cells indicate the number of service companies that have responded either yes/being developed/ no/will like to use/no response. The survey shows that out of 43 service companies surveyed, 38 were aware of JIT. A good number of companies about 50%, indicated benefits and scope of JIT implementation in India. Out of 43 service companies surveyed, majority of the companies are using or will like to use computer and information technologies (CIT) based tools in their companies.

Table 2: state of the use computer and information technologies (CIT) tools

Tools	Yes	Being Developed	No	Like to use	No response
QFD	17	6	9	3	8
SQC	24	8	7	1	3
Expert systems	17	6	9	4	7
Shared data bases	27	3	4	4	5
Decision support system	19	4	10	4	6
Preventive maintenance	31	2	5	3	2
Automation and autonomation	20	6	5	3	9
Benchmarking	16	12	2	1	12
Electronic communication	33	5	1	1	3
TQM	19	5	4	3	12

Analysis of responses

The majority of managers indicated that a very good weightage is being given to JIT elements in their respective companies. The value of the mean score for each of the JIT elements is calculated in Table 3, which shed light on the relevancy of JIT elements in the service companies surveyed. The values of mean scores in Tables 4, 5 and 6 give expected benefits and degree of problems in the implementation of JIT and JIT elements, which are comparatively easy to implement.

Results with respect to main JIT elements, problems in implementation, expected benefits and JIT elements which are comparatively easy to implement with a calculated mean on a scale of 0-100 are presented in Table 7.

According to the results, the top five JIT elements included cost cutting, Computer and information technologies (CIT), Supplier management including vendor selection and evaluation, Total Quality Control, Team work/cross-functional teams.

Among the other results, the main benefits that are expected as a result of JIT implementation include improvement in profit margins, traffic time, administrative

Table 3: Importance of JIT elements as perceived by the respondents

JIT elements ↓	Very good	Good	Average	Below average	No response	Mean score 0-100
Score →	4	3	2	1	–	–
Cost cutting	19	15	7	0	2	82.25
Computer and information technologies (CIT)	18	17	6	0	2	82.25
Supplier management including vendor selection and development	16	19	6	0	2	81.00
Total quality control	15	22	4	1	1	80.25
Top management support	15	22	6	0	0	80.25
Team work/cross functional teams in different aspects	16	19	6	1	1	79.75
Technical support	15	20	7	0	1	79.75
Simplification of procedures	17	17	7	1	1	79.75
Continuous improvement	14	20	5	1	3	79.38
Inventory reduction at every stage	19	12	8	2	2	79.25
House keeping (Orderliness, tidiness, clarity/cleanliness)	14	22	5	1	1	79.25
Preventive maintenance	17	17	8	1	0	79.00
Communication and information sharing	17	16	7	2	1	78.50
Customer care	12	22	7	0	2	78.00
Flexible/multifunctional workforce	15	20	6	2	0	78.00
Design for service	8	28	4	0	3	77.50
Flow/ Layout	14	15	9	2	3	75.63
Employee involvement	10	24	7	1	1	75.50
Intolerance to waste and nonvalue added activities	13	19	10	1	0	75.50
Smooth flow	10	20	9	1	3	74.50
Process improvement and simplification (process design)	11	18	8	2	4	74.25
Set up time reduction	10	18	7	3	5	73.00
Standardization	10	20	7	2	4	72.50
Lead time/response time reduction	10	19	10	2	2	72.50
Workcells/organization in modules or cells	13	11	12	3	4	71.75
JIT purchasing	10	16	8	5	4	69.75
Warehouse/storage space elimination	7	18	9	3	6	69.50
Waster eduction (unreasonableness, unevenness, waste)	5	24	8	3	3	69.50
Standardized containers	8	17	5	6	7	68.75
Kanban/ demand driven material movement method	9	12	9	6	7	66.75
Lot size reduction	6	14	14	3	6	64.25

efficiency, costs, and customer care. Lack of top management support, management participation, employees' support, and middle management support and management resistance were the main problems as perceived by respondent service organizations. JIT element of quality improvement techniques, standardization, process simplification, lay out improvement, quality circles, are comparatively easy to implement.

Concluding Remarks

The survey results indicated that JIT is quite relevant

Table 4: Expected Benefits of JIT implementation as perceived by respondents

Benefits ↓	Very high	High	Average	Low	No response	Mean score 0-100
Score →	4	3	2	1	–	–
Extent of improvement in profit margins	18	18	2	2	3	84.38
Extent of improvement in traffic time	12	14	8	3	6	83.78
Extent of improvement in administrative efficiency	18	18	4	2	1	82.74
Extent of improvement in costs	19	17	5	1	1	82.14
Extent of improvement in customer care	17	18	7	1	0	81.40
Extent of improvement in processing of paper work	20	14	6	2	1	80.95
Extent of improvement in competitive position	19	13	7	2	2	79.88
Extent of improvement in system's flexibility (response to change in demand)	16	17	5	2	3	79.38
Extent of improvement in service provided	16	19	5	2	1	79.17
Extent of quicker resolution to problems	15	21	6	1	0	79.07
Extent of improvement in communication	15	21	6	1	0	79.07
Extent of improvement in team spirit	15	19	5	2	2	78.66
Extent of improvement in reducing the number of suppliers	14	20	1	4	4	78.21
Extent of improvement in productivity	14	21	5	2	1	77.98
Extent of improvement in quality	15	18	8	1	1	77.98
Extent of improvement in worker utilization and efficiency	15	16	5	3	4	77.56
Extent of change in performance measures	13	22	5	2	1	77.38
Extent of improvement in response time	14	19	8	1	1	77.38
Extent of improvement in material handling	13	19	4	3	4	76.92
Extent of recommendations of Jit to others	13	17	9	1	3	76.25
Extent of improvement in equipment utilization and efficiency	14	19	6	3	1	76.20
Extent of improvement in relations with suppliers	12	21	3	4	3	75.63
Extent of improvement in vendor performance	11	20	8	1	3	75.62
Extent of reduction in space requirements	13	17	5	4	4	75.00
Extent of improvement in backlog reduction	9	22	7	2	3	73.75
Extent of improvement in forecasting	10	22	5	4	2	73.17
Company's readiness for JIT implementation	14	15	9	3	1	72.62
Extent of simplified ordering and receiving procedures	8	20	8	2	5	72.37
Extent of improvement in inventory reduction	6	26	5	3	3	71.88
Extent of enhanced buyer awareness	9	16	9	5	4	68.38

in the Indian service sector as perceived by respondent service organizations. The results obtained can further be subjected to statistical testing like t-test and Chi square tests to obtain some important conclusions. Further work is possible to see the impact of JIT on service quality. The data has been collected to measure the extent of JIT use in service organizations along different JIT elements. Service quality data can be collected using SERVQUAL instrument, (Parasuraman et al. 1988). Servqual is a multi-item scale for measuring customer perceptions of service quality. It measures service quality along five dimensions: tangibles, reliability, responsiveness, assurance, and empathy. Data collected can be subject to further analysis with statistical techniques such as regression where JIT elements are independent variables and service is the dependent variable. Factor analysis, (Nunnally, 1978) can

Table 5: Problems in implementation of JIT attributes

Problems ↓	Not at all	Little	Fair amount	A great deal	No response	Mean score 0-100
Score →	4	3	2	1		
Problems on part of Management						
Lack of management support	21	17	4	0	1	82.31
Lack of management participation	21	11	9	0	2	82.31
Management resistance	17	20	5	0	1	82.14
Lack of middle management support	16	15	9	0	3	79.38
Poor response to innovation and change	17	11	13	1	1	76.19
Poor forecasting	12	15	11	0	5	75.65
Lack of knowledge about JIT	18	13	6	6	0	75.00
Lack of education and training of those involved	17	10	12	3	1	74.41
Problems in revising the roles and responsibilities	14	15	9	3	2	74.39
Problems in the identification of areas where to apply JIT	15	14	10	4	0	73.26
Lack of good performance measurement system	14	13	13	2	1	73.21
Environmental problems	12	18	9	4	0	72.09
Problems in the change of organization culture(New attitudes and skills)	15	12	9	6	1	71.43
Lack of formal training for managers	15	12	9	6	1	71.42
Doubts about benefits of JIT	0	12	16	13	2	49.39
Problems on part of Employees						
Lack of support from employees	16	20	6	1	0	79.65
Lack of communication between management and employees	15	17	9	2	0	76.16
Lack of multifunctional workforce	14	18	8	3	0	76.16
Lack of flexible workforce	13	17	12	0	1	75.60
Poor response to innovation and change by employees	14	16	12	1	0	75.00
Management resistance to share authority with employees	12	19	7	4	0	71.51
Lack of knowledge about JIT on part of employees	10	18	11	4	0	69.76
Attitudinal differences problems	3	15	15	9	1	57.14
Problem of internal inertia that discourages JIT	2	12	15	13	1	51.78
Problems on the part of Suppliers						
Quantity problems with supplied material	15	18	3	0	7	83.33
Environmental problems	12	18	6	3	4	75.00
Transportation problems	10	20	8	1	4	75.00
Lack of communication with suppliers	11	16	10	1	5	74.34
Resistance to innovate on the part of suppliers	9	19	7	3	5	72.37
Timing problems with supplied material	7	21	7	2	6	72.29
Lack of support from suppliers	8	19	8	2	6	72.29
Quality problems with supplied material	6	23	5	3	6	71.62
Lack of knowledge about JIT on part of suppliers	5	17	10	5	6	64.86

Table 6: JIT elements, which are comparatively easy to implement

JIT elements ↓	Highly difficult	Fairly difficult	Little difficult	Easy	No response	Mean score 0-100
Score →	4	3	2	1		
Communication within the company	1	9	16	14	3	48.12
Quality improvement techniques	1	12	12	17	1	48.21
Standardization	0	13	15	14	1	49.40
Process simplification	1	12	14	14	2	50.00
Layout improvement	0	13	14	13	3	50.00
Quality circles	2	9	17	11	4	50.00
Team and cooperative team work	2	7	21	11	2	50.00
Availability of accurate data	1	12	17	13	0	50.58
Technology/engineering support	1	12	15	13	2	50.60
Reliability of machinery and equipment	2	9	16	12	4	50.64
Kanban	0	10	16	9	8	50.71
Work in process reduction	1	8	22	8	4	51.28
Process flexibility	1	13	16	11	2	52.44
Transportation reliability	1	12	18	9	3	53.13
Process improvement	0	15	18	9	1	53.57
Long term employment	2	10	20	8	3	53.75
Maintenance	1	10	20	6	6	54.05
Inventory reduction	3	8	20	7	5	54.60
Cost reduction	1	15	18	8	1	55.35
Identification of problems	3	12	18	9	1	55.35
Conducive culture	5	13	15	10	0	57.56
Organizational modification efforts	3	19	10	11	0	58.14
Right implementation strategy	4	14	15	10	0	63.37
JIT purchasing	3	14	12	9	5	67.10

Table 7: Survey Results on a scale 0-100

Importance of JIT elements as perceived by respondents	
JIT elements	**Mean score**
• Cost cutting	82.25%
• Computer and information technologies(CIT)	82.25%
• Supplier management including vendor selection and development	81.00%
• Total quality control	80.25%
• Team work/cross functional teams in different aspects	79.75%
Expected Benefits of JIT implementation as perceived by respondent	
Benefits	Mean score
• Extent of improvement in profit margins	84.38%
• Extent of improvement in traffic time	83.78%
• Extent of improvement in administrative efficiency	82.74%
• Extent of improvement in costs	82.14%
• Extent of improvement in customer care	81.40%
Problems in implimentation of JIT Attributes	
Problems	Mean score
• Lack of top management support	82.31%
• Lack of management participation	82.31%
• Management resistance	82.14%
• Lack of support from employees	79.65%
• Lack of middle management support	79.38%
JIT elements which are comparatively easy to implement	
JIT elements	Mean score
• Communication with in the company	48.12%
• Quality improvement techniques	48.21%
• Standardization	49.40%
• Process simplification	50.00%
• Lay out improvement	50.00%

also be employed in analyzing the data if one is interested in finding the top "X" JIT elements potentially affecting service quality.

JIT index for benefits and scope of JIT implementation in India is calculated for different types of service industries and results are tabulated in Table 8.

Table 8: JIT index on a scale 0-4

Benefits of JIT Implementation	
Type	**JIT Index**
Education	3.75
Banks	3.50
Maintenance	3.00
Manufacturing	3.40
Hospitals	3.40
Consultants	3.75
Others	3.25
Scope of JIT implementation	
Type	JIT index
Education	3.50
Banks	3.33
Maintenance	3.40
Manufacturing	3.50
Hospitals	2.80
Consultants	2.50
Others	3.00

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Feature

Informalization of Global Labour & Survival of Local Workers

Bhaskar Majumder

The paper shows the co-existence of labour in the informal and formal sector. It also records the type of workers and work opportunities in a mixed scenario of local-regional economy. It focuses on family as the decision-making unit that determines the mobility of the individual, as opposed to the individual's own optimization decisions. The paper opines that the occupational pattern being heavily weighted in favour of land-based activities, the scope for workers getting converted into 'global labour' is limited. The paper points at the necessity to convert caste division of labour into economic division of labour if the local worker is to get converted into global labour. This will also expose the problems of employment, unemployment and underemployment in an economy in transition.

Bhaskar Majumder is with the G.B. Pant Social Science Institute, Allahabad-211 019.

The post-Second World War world globalized in a bipolar world and the post-Cold War world globalized in a unipolar world. Macro economic stabilization and structural adjustment policies (SAP) advocated by multilateral agencies like the World Bank (WB) and the International Monetary Fund (IMF) are the components of globalization. These components are either accepted by the countries globalized by membership in the global bodies like the WB, the IMF, the GATT (the WTO since 1995) or are imposed on them. For example, the Government of India declared its New Economic Policy (NEP) in 1991 as a condition of this SAP (Bhalla 1995). The NEP, 1991, aimed at ensuring a 'much freer play of market forces' (GOI, 1991).

The NEP was supposed to have implications on the location of labour vis-à-vis capital. Families are the immediate suppliers of labour while they are the remote suppliers of capital. Capital comes to its controllers (firms) through financial institutions that collect savings (money) from the families. However, the participation of the workers comes through the existence and operations of firms. These firms control both capital and labour, and coordinate between these in the sphere of production. The individual as a labourer sells her labour power where the firm, as the owner or controller of capital, agrees to buy it. This, at the same time, shows the control of capital over labour.

The integration of the economies around the world through the globalization agenda aims at non-discrimination between home and foreign firms. The countries like India generally depend for technologies and investment on foreign firms. 'Non- discrimination' in the globalization agenda means offering 'home treatment' for foreign firms in the host country where the home firm is located. A cordial relationship between foreign firms and home firms on the home soil means also rationalization of firms through a number of means. These means may include technological upgradation, shifting control of capital from the public to the private,

downsizing of workers etc. These may again lead to informalization of the labour force and decline of labour power in two ways, one through decline of trade unionism, and the other through decline in real wage rate. Both these ways are inter-linked, the latter follows the reduced bargaining power of labour vis-a-vis capital. The assumptions of the paper are the following:

(i) We consider labour as input in production just as capital (non-labour) is. The expression of this labour-power (a commodity that is offered by a worker for sale and consented to be bought by the controller of capital) is labour hour. This labour hour gets concrete shape in products produced in a firm/farm.

(ii) We consider a worker as an individual who does any job/work independent of the time rule (labour hour) and collects/produces goods for herself (including her family). The worker always exists as a social category, while labour exists as an economic category.

(iii) It needs institutions to convert a social category into an economic category, hence, to convert a worker into a labour/labourer.

(iv) There is at least one individual behind 'work' that is performed on nature, while there has to be at least two individuals for operationalization of 'labour'.

We are going to examine two propositions: (i) The occupational pattern being heavily weighted in favour of land-based activities in the locality, the scope for workers getting converted into 'global labour' is limited. (ii) The conversion of socio-cultural families into economic individuals can convert a local worker into a global labourer.

Job Opportunities and Informalization of Global Labour

Increasing job opportunities, and hence increasing labour mobility, is an integral part of the formation of 'global labour'. The changes in technology, particularly the electronic speed of work, have given birth to a new pattern of work organisation from the side of controllers of capital. With respect to technologies moving in an ascending order, thereby saving production (labour) time, there has come a task for both the actual and the potential workers to acquire multi-skills in addition to upgradation in the skill that the worker acquired while joining the current job (ILO, 1997-98). The generation of more advanced technology globally with information transmitted locally has reduced the importance of workers' proximity to the final market for the product.

People were mobile, independent of the globalization agenda, in the post-Second World War period. This was not only because of trade but also curiosity to know the rest of the world. The discoveries since the 15th century, in particular of countries through the sea route, bear testimony to this globalization. The rules regarding passport and visa are of recent origin and, in fact, restricts the free movement of people. There is also another type of movement of people, that is, the 'drawing' of people as slaves and indentured labourers from the countries conquered and colonized. The non-occurrence of 'coming back' of the people who moved out willingly and the people who were 'drawn out' came to be used in the sphere of production and related activities in the countries where they 'moved in' or were 'drawn in'. This, at a later stage, came to be recorded as components of labour force of foreign origin. In any case, the use of foreign-born labour force is an indication of global labour, among many other indicators (Table 1).

Table 1: Foreign-born Labour Force in OECD Countries (As percentage of total labour force, Selected Years)

Foreign Labour Force in	1990	1997
UK	9.4	10.8*
France	6.2	6.1
Germany	7.1	9.1
Japan	0.2	1.0
Italy	–	1.7
Canada	18.5	18.5*
Austria	7.4	9.9
Belgium	–	7.9
Denmark	–	3.1
Ireland	2.6	3.4
Luxembourg	45.2	55.1
Netherlands	3.1	2.9
Norway	2.3	2.8
Portugal	1.0	1.8
Spain	0.6	1.1
Sweden	5.4	5.2
Switzerland	18.9	17.5
Australia	–	24.6

* Data relate to 1996.

Source: ILO, 2001, World Employment Report, p.19.

Implications of Table 1

First, because of use of slaves in the remote past and their ultimate settlement in countries like the US, the

percentage of foreign-born labour remains high even now.

Second, the high share of foreign-born labour in total labour employment may show more of intra-OECD adjustment in labour force that limits ethnic composition of workers and hence, invites lesser ethnic conflicts in the OECD countries.

Third, for countries like Canada, this may be because of initial necessity to cover by production huge territorial areas, particularly for agricultural purposes, and hence, the high percentage of foreign-born labour in Canada may reflect the initial open-door policy for entry of labour from abroad.

Fourth, the percentage as a whole for all the countries in OECD may fail to show a high percentage of labour settled in these countries that continue to move out from the Third World countries. The TWCs have around three-fourth of the world population. If, as a rough approximation, one-third of this population is in the working age, then one-fourth of the world population will be available in the TWCs as population in the working age. The OECD countries, as a whole, have population less than one-fourth of world population, implying that the OECD countries may provide the job space for, at most, one-twelfth of the world population. It is an absurd idea that the OECD countries will provide space for even this one-twelfth of world population, that is, one-third of settled population in the working age in the TWCs.

The OECD countries, thus, can not continue to be a destination for the population in the working age in the TWCs. This is not to imply that there should not be any 'globally competent' person seeking absorption in any of the OECD countries, or creating scope for movement across OECD countries.

Implications of Table 2

Prime facie, the data for all the countries based on regional average show similar rates of labour force participation. India conforms to this pattern. The data show nothing more than a size of population in the specified age bracket that deem to be economically active. What the data fail to capture is the very nature of employment. In the less developed regions comprising countries in Asia (excluding Japan), Africa and Latin America, most of the people remain dependent on land (agriculture). The social structure in most of these countries being accommodative and the economic structure being pre-capitalistic, the people in the working age remain less mobile. Underemployment or low- productivity based employment is the corollary.

Table 2: Labour Force Participation Rates at Age 15-64, 1980-2000 (Selected Years)

Region/Country	1980	1995	2000
World	72.6	73.0	73.3
More developed regions	71.4	72.7	73.1
Less developed regions	73.1	73.4	73.4
Least developed regions	78.7	77.2	76.8
India	68.9	66.4	66.6

Source: ILO, 2000, World Labour Report, p. 267-268.

Ground Reality

Most of the population of both working and non-working age (children and aged) in the Third World countries depend on agriculture for mere survival. The questions related to the pattern of labour employment like part-time, casual etc are meaningless in most of these cases. In a large country like India by size of total population, and hence population in the working age, this means absence of any choice for the individuals in families other than being dependent on land. All the Census data since 1961 on percentage distribution of the workforce in rural India have shown hardly any change for both male and female. For male workers the percentage varies between 76.0 and 81.0 per cent and for female workers it varies between 84.0 and 88.0 per cent. The National Sample Survey (NSS), which has followed comparable definitions on employment and unemployment, shows a similar trend (NIRD, 1999, p. 55-56). The economic life of most of the population is really embedded in its socio-cultural life. For most of the population it is the ritual, or the tradition, that determines whether the economic practices can be at all pursued. These rituals and tradition-based practices are really reflections of caste and gender dependent exclusive practices. Production in any locality, generally a village or cluster of villages, is often not based on monetary exchange. Either it is for self-consumption or for sharing within the locality, whether or not barter-based. In absence of 'production for money-based exchange' the products that come out from land-cum-unskilled labour remain generally unprocessed or less processed. The consequences are obvious. In absence of technological change, or in a state of ignorance about technological change elsewhere, or inability or unwillingness to apply the advanced state of technology, the production structure remains primitive and localized. It also leads to low land-cum-labour productivity. There is fear that technological change when applied might lead to displacement of a section of the initial 'wage workers'. The second one also may

imply surrender (leasing-out) of small plots of land to the big landholders, because advanced technology happens to be too costly for the very small farmer, by size of land holding and the capacity to input-use, to adopt.

Underemployment

The calculation, theoretically, on the size of under-employment or disguised employment, does not lead us to far. Whether or not dependent directly on land, it is generally accommodative family labour where the distinction between the buyer and the seller of labour power is blurred. Even if, thus, the number of days in any particular year (less than 180 working days) is taken as the basis of identifying the underemployed worker, in practice it becomes rarely possible. First, it is not very clear what section of the workers engaged at present will be declared surplus and, then, what consequence they will face. Second, who is going to declare them surplus and then work as a catalyst to reemploy them? Third, if it is productivity (marginal, which is not applied on the field) calculated for existing workers, there may come a 'technology solution' whereby the existing capitalist farmers will try to rationalize their farms by 'hire and fire'. The question remains for most of the non-capitalist farms in economies like India where workers are socially-culturally accommodated in the economic space also.

Identification of the Worker

There is no single work for many of the workers. This is not to be read as diversification of jobs that a worker chooses to perform. There is, in fact, no choice for the worker other than trying to minimize the vulnerability by maximizing the number of days she gets the opportunity to work. This work opportunity is also not always clear unless she moves in a state of uncertainty to offer her skill anywhere. While this may lead to the problem of identification of the worker, it also complicates the calculations discussed so far. While land productivity can be measured by physical volume of output, worker productivity may be made fuzzy by price manipulations. In case of multiple jobs, often by distress as opposed to diversification, income-criteria is thought of to identify the worker. Thus, if individual X is self-employed in agricultural work for eight months a year and earns Rs. 20,000 in total, while she works in a mill for four months as casual worker and earns Rs. 20,001, she will be called a casual (wage) worker (freeter). If X works for six months a year in agriculture and earns Rs. 15,000 while in a mill she works six months to earn Rs. 30,000 she will, for sure, be called a casual (wage) worker. In the former case, we need to take care of the time spent in agricultural activities and in both the cases we need to take care of the attachment of the individual to land. The point is that whatever temporary job the individual selects, she is land-based for not only earning but also for stable living. Hence, it will be more rational to identify the worker as an agricultural worker, whether she is self-employed in agriculture or employed by others. In case of self-employment, this argument will invite fewer debates.

Economic dynamics take a particular shape when the prevailing mode of production is pre-capitalistic (that is, a hierarchic arrangement of people in the social ladder, people interacting by visible personal relations) and a different shape when it is capitalistic (that is, impersonal social relations indicated by the invisible market). In the former, revealed physical force works, rationalized by 'tradition', precedence', 'convention' etc, while in the latter, coercion is hidden under the guise of market forces (for example, via exclusion of people not possessing any marketable property or exit of people by the forces of the market). In the former, people are included by caste-custom-prejudice etc, while in the latter people are included on the basis of money (Majumder, 1997). For most of the workers traditionally depending on land, as in the non-capitalist agricultural regions in India, the economic division of labour lives essentially in the womb of the caste division of labour. In this frame the workers feel comfortable to move out from land (agriculture) to land (agriculture). This may be one reason why there often occurs movement of workers from rural Bihar to rural Punjab, and movement of workers from rural Orissa to rural Gujarat. The familiarity of the new environment (including job environment), historically-culturally, and not necessarily by wage negotiations, helps this movement.

In India, the economic division of labour lives essentially in the womb of the caste division of labour.

Workers and Work Opportunities in a 'Local-Regional' Economy

In localized economies of most of the underdeveloped countries, family bondage works more than the mobility of the individual in the working age. The family as a whole provides income security. It is a collective/accommodative economy where family priorities come ahead of the individual's self-priorities. The family is the economic unit, not the individual. The revealed choices of an individual are really the reflection of simultaneous decisions of all members in

the family that attempt to optimize family welfare, with the gains and losses of all the members of the family entering into the decision. Decisions on migration are no exception.

Often people settled in an underdeveloped region move in a state of limited knowledge about job opportunities. This limited knowledge is derived from past practices of the same individual or the practices of her past generation. The small underdeveloped locality offers limited social safety and insignificant economic safety. The individual, depending on the socio-cultural characteristics of both the localities 'moving out' and 'moving in', moves with and without families. The 'twin localities' show scope for work for the 'moved out' and 'moved in' individual. This is not the same as wage-differential determined labour mobility. Generally people settled in villages in underdeveloped regions prefer to stay inside the villages by attachment to land, other animals, relatives, and local environment in its totality. The cultural factors like language, rituals also, reinforce this tendency to remain attached to the locality. In fact, in such localities, land-based activities remain symbols of broader life, and not simply an economic occupation.

While the society-cum-culture works as bondage for the individual, non-development of the local economy drives the individual out. A mismatch between economic compulsions and socio-cultural taboos that often prevail in underdeveloped localities may drive the individuals out. The individual moved out thus may become an economic individual when she 'moves in' to an economic job elsewhere. Let us present a few examples.

While the society-cum-culture works as bondage for the individual, non-development of the local economy drives the individual out.

Example 1: It is not necessarily true that the locality of an income-cum-asset poor individual is the village for economic purposes. The individual moves to regions for economic survival of her family not only outside the village where she is settled by birth but even beyond her national orbit. During pre-monsoon and monsoon months (June-Sept), the income-cum-asset poor individuals move out of Bangladesh and enter West Bengal, particularly in and around Kolkata, in search of jobs. These people mend umbrellas in which they have skill by heredity practices. They know the local language where they 'move in' and are accommodated. They go back to Bangladesh after they have earned income in cash.

Example 2: People are brought from the Nwada region of the state of Bihar generally in families to work as workers in the brick plants located at a distance from Kolkata in West Bengal. These income-cum-asset poor people work for around six months (Oct- March) a year, live in temporary sheds inside the brick plant, they earn income in cash and go back after the production period. One 'Munshiji' (labour contractor) is generally used to bring these workers for which the contractor is paid cash in advance by the owner of the plant. A part of this initial payment is distributed among the heads of the 'drawn out' families even before the workers are absorbed in the brick plants. This is supposed to ensure security for the rest of the members of the families 'drawn out' from the villages in Bihar. This movement of workers could be from anywhere to anywhere. Often it is directionless.

Example 3: The high-caste landless individual may face socio-cultural barriers when he likes to be hired by others to do a manual (menial) job inside the same or adjoining village in East Uttar Pradesh. The individual moves out to Kolkata. He works as a taxi driver earning well and gets settled there. This is culture-led forced migration. The type of job that this individual does in Kolkata because of the anonymous character of a metropolitan city could not be possible in the villages in an underdeveloped region and even in the small towns where the high caste individual has root by birth.

Example 4: The individual who got settled in Jadavpur area, adjacent to Kolkata, long back since his early years selling cheap snacks on the road-side mobile stall had to come back to the village adjacent to the city of Allahabad in Uttar Pradesh. The individual has come back to his native village. The individual continues to do the same job, that is, selling cheap snacks prepared on a mobile stall with a 'chullah' fixed inside on the road-side of the city of Allahabad. The individual, along with his family, stays in the village at a distance of around 10 k.m. from the city, 'moves in' the city every day in the morning and 'moves out' in the afternoon. He had to come back from Kolkata that offered him higher earnings per day, because the Government of West Bengal took the decision to reconstruct roads- cum-pavements and hence the individual could not take any chance to be again rehabilitated there. Nor could he wait to be rehabilitated.

In all the cases, it is the survival instinct of the individuals and families that matter in taking decisions regarding economic activities, often under compulsion. The examples that we have cited do not show any uniform pattern in terms of income/wage received and

other practices by utilization of time per day. However, all of them show a situation of initial income-cum-asset poverty, absence of conversion of the locality considered as a socio-cultural unit into an open economic unit, and hence, for some individuals and families the urgency to 'move out'. In general, the written, formal contracts governing the economic exchanges between buyers and sellers, and between employers and employees, are absent in such movements because of pre-capitalistic institutional arrangements.

Labour Mobility vis-a-vis Workers' Search for Jobs

Capital is mobile because of decisions by the controllers of capital. The financial institutions as custodians of capital follow the users of capital. The knowledge of workers can move at an electronic speed, but not the worker herself. The way the workers get affected by the utilization of capital and other factors are obviously not the same as the way the capital and other inanimate factors are affected. The way labour, capital, and other factors are affected, are linked with factors like market size, technology, access to market etc. Many of these determining factors are also linked with, as both cause and consequence of, workers' decisions at the levels of plants, laboratories, planning, education, training etc.

The mobility discussed in literature often rules out dual existence of man. The individual as an economic agent is assumed to be not a casual (part-time) worker, nor does she share jobs in exchange of income of any type seasonally/occasionally. She is assumed not to be in distress to sell anything that she may be collecting from common resources. She is assumed to have saleable labour (labour-power as a commodity) for which she readily finds a buyer. This shows a very limited frame of analyzing workers' (often potentially existing) economic existence and mobility.

Immobility and Restricted Mobility of Workers

The industrially less developed countries, in general, are characterized by immobility of workers. This is not because of the unwillingness of the workers to be mobile but because they are not informed about 'better' job opportunities elsewhere. Even when jobs of any type are available and known to the worker, she may not be in a position to be present everywhere because of the initial cost involved, like travel cost and costs for many other necessities.

The worker calculates a trade off between benefits that the new job will provide her and the costs that she will have to incur. These costs are not visibly always monetary. The non-wage factors include the accommodation of the worker's family, the education of the children in a new region with all new linguistic-cultural implications, the service facilities in the new region, the existing occupation of the spouse, the dependents in the family etc.

The worker calculates a trade off between benefits that the new job will provide her and the costs that she will have to incur.

Often the hiring of workers in a less industrialized economy is hiring of all the members in the family. This may be seen in construction works supervised by a contractor, generally in an urban area. This may also be seen in brick-kilns located generally in rural areas adjacent to a final (urban) market where workers are brought from distant rural areas. The urban owners or plant managers of the brick kilns take the help of a contractor ('Munshiji), generally with knowledge of rural areas, to get the family labour hired. Both these types of workers are employed seasonally. While in the former case it is for a temporary period (depending on the cost-benefit calculations of the labour contractor), in case of the latter it is season-specific (Oct- March). These family workers are not self-employed, but employed by others and in the informal sector. Temporary/seasonal employment for a period does not guarantee job opportunities for periods to come. If the job to come in the next period is not known, any future movement of these workers remain uncertain and footloose. There may remain a big geographic distance between the spaces where these workers expect to get jobs. These workers, being economically vulnerable, can not bear the cost of moving in a state of uncertainty. Hence, they are taken forward by the labour contractors for any future job settlements. These workers, thus, are not really mobile, but show the characteristics of indentured labourers.

On the assumption that the initial absorption of workers in a particular plant was rational, it will be rational for a firm to discourage the exit of skilled workers. There is, thus, internal obstruction for a worker's mobility. This obstruction is not always visible. The same firm, however, encourages the entry of workers who have proved themselves skilled in other plants, thereby inviting mobility. The prevailing technology does not throw workers out, but the improving technology shows the path of eviction of a section of workers. This is to be contrasted with mobility of workers. Training of workers by job rotation inside a plant, or at an inter-firm level, shows shift of workers, and not necessarily mobility by promotion. The project-specific displacement is inde-

pendent of the choice of the people in the working age, along with their families. The eviction of settled people from the land is another example of displacement. These workers may seek jobs anywhere in the national economy, or, even outside the national boundary. The people in the working age may shift to the neighbouring country, independent of the choice of the affected people, because of war, partition etc and seek jobs in the new settled region.

Engagement in a number of jobs does not always show stability by reduced vulnerability in 'one job', but may show vulnerability of the worker herself when the single initial job is not dependable. In a conventional sense, this dependability is subject to the existing market conditions and, hence, the return that the job offers throughout the year and over the years. In reality, the initial job that the individual is thrown into becomes fait accompli where she gets attached since her childhood. It may be land-related jobs, it may be any job in the unorganized sector. Natural calamities in the former by flood, drought and absence of any protection of workers through labour laws etc. in the latter, keep the workers vulnerable.

The workers' resistance to new entry in the organized sector may obstruct worker's mobility. This obstruction is really for those who like to move within the organized sector. Often inter-firm mobility of workers may be obstructed by political influence. Mobility of workers may also be constrained by non-innovative or stereotype jobs, where internal workers 'do the job'. Often the entry of individuals into the job market is 'time-tied', markers' mobility non-operational for a stipulated period. Some types of entry may be delinked from any guarantee of jobs, for example, Apprenticeship Schemes. Any mobility from the informal to formal sector is an uphill task. Often an attempt toward this may show slumaization and deruralization (Breman, 2003).

Concluding Comments

The task is to convert social categories into economic categories. In the context of labour, it means conversion of caste division of labour into economic division of labour. This reveals both the inner weaknesses in a system and the need to reorient the system. A positive step towards exposing the problem of unemployment and underemployment would be to plan for training, job-rotation, and placement of the workers on jobs that are based on and consistent with the knowledge base of these workers. Development of agriculture-related activities on an industrial basis, development of rural infrastructure, and development of local resource-based rural industries are the major routes by which these populations can be productively settled. The state has to be the catalyst for these.

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The joy is in creating, not maintaining.

– Vince Lombardi

Feature

Work Climate in a Government Department: An Empirical Study

Sunil K. Dhawan & Suresh Kumar

After a systematic literature review, this paper undertakes an analytical and explanatory study of answers to questions on well being, job satisfaction, motivation and work climate of government employees under a ministry with respondents ranging from Assistant to Joint Secretary.

Sunil K. Dhawan and Suresh Kumar are Scientists with the National Institute of Science Technology and Development Studies, KS Krishnan Marg, PUSA, New Delhi-110 012.

Organizational research presents two conflicting views of the human or attitudinal outcomes of bureaucracy. According to the negative view, the bureaucratic form of organization stifles creativity, fosters dissatisfaction and demotivates employees. According to the positive view, it provides needed guidance and clarifies responsibilities; thereby easing role stress and helping individuals feel more effective.

Government departments and ministries are often seen as a centre for bureaucratic organizations. The vast majority of these employees work in establishments with extensive formal procedures' written job descriptions, and clear-cut rules and procedures manuals (Marsden, Cook, & Knoke, 1994; Dumaine, 1991; Heckscher & Donnellon, 1994). Literature also highlights the tensions between the recommendations of the concepts - total quality management (TQM) and employee involvement (EI), currently offered by management experts (Lawler, 1994). TQM's emphasis on work process codification seems to contradict EI's focus on increasing employee discretion, a contradiction similar to that between the "lean" and "team" approaches described by Applebaum & Batt (1994). The conflict between these approaches is particularly visible in the debate over appropriate organizational and job designs in repetitive operations (Womack, Jones, & Roos, 1990; Berggren, 1992; Adler & Cole, 1993). Similar debates concern the organization for far less repetitive activities (Cusumano, 1991; Lecht, 1991; Soat, 1991). These debates reflect contradictory assessments of the core features of the bureaucratic form – workflow formalization, specialization, and hierarchy.

At the same time, there is a continuous rise in theories related to climate, job satisfaction/dissatisfaction, and participative management. The assumption behind this rise is the increasing recognition that organizational members often have something valuable to contribute (beyond the accepted limits of their normal job duties), many organizations, including government

departments and ministries, are actively seeking ways of getting members to participate at least on those decisions which affect them (Presthus, 1961). However, the strong hold of the bureaucratic system in the mental set-up of employees often restricts their participation to anywhere near the desired level (Crozier, 1964; De, 1981; Dhawan, 1985,1999,2000,2001). Some of the other obstacles to participation are: (i) many employees fear that expressing their true feelings about the organization to the management could be dangerous, (ii) the fairly widespread belief that disagreeing with the management will block promotion, (iii) the widespread conviction that management is not interested in employees' problems, (iv) the feeling that members are not rewarded for good ideas, and (v) the conviction that senior management does not take prompt action on problems (Hamner,1980; Dhawan, 1999).

These barriers to active participation in organizational decision-making and functioning, on the one hand, reflect the value system of the people and, on the other hand, it also highlights their level of acceptance or satisfaction with the existing system. Their desire to accept any change, small or big, in the given structure, depends on how much these barriers are taken care of. Thus, if we wish to bring any meaningful change in the functioning of the government departments and ministries, a proper understanding of members' perceptions about work climate and job satisfaction/dissatisfaction should be adequately accounted for in the "Action Plan".

Work Climate: The Concept

Let us begin with how work climate/environment has been defined by various researchers in literature. Some scholars dealing with it theoretically have argued in favour of splitting "Organizational Climate" into two parts: individual – focused and organization – focused (James & Jones, 1974; Dhawan & Roy, 1991). Roy & Dhawan (2002) have also argued that the work climate portrays the organizational environment as being rooted in an organization's value system, but tends to present the social environment in relatively static terms, describing it in terms of a fixed set of dimensions. Thus, the climate is often considered as relatively temporary, subject to direct control, and largely limited to those aspects of social environment that are consciously perceived by organizational members (Joyce & Slocum, 1984; Koys & DeCotiis, 1991).

Some authors defined climate in terms of organizational attributes, "psychological climate" and "individual attributes". Hellreigel & Slocum (1974), by contrast, treated it as a more unitary phenomenon, defining it as "....a set of attributes which can be perceived about a particular organization and/or its subsystems, and that may be induced from the way that organization and/or its subsystems deal with their members and environment". Schneider & Snyder (1975) defined climate as "a global (multidimensional) impression of what the organization is". Menon & Shamanna (1990) have indicated that the interpersonal relationships that prevail within an organization are influenced by the nature of the work in that organization. Interpersonal relationships can affect productivity and this can modify the satisfaction that employee derives from his job. Sherman & Olsen (1996) have examined differential characteristics of organizational climate and the relationship between various dimensions of organizational climate and performance across the stages of the project life cycle in research organizations. However, as it is defined, "climate" refers to a systematic phenomenon that pervades an organization and its parts. In addition, climate is a perceived phenomenon, knowledge of which is gained by administering and scoring questionnaire(s) (Dhawan & Roy, 1991). This study has also used a questionnaire to measure work climate.

Organizational climate can be split into two parts: Individual focused and Organizational focused.

Some other authors like Argyle (1989), argued that satisfaction with work climate is one of the three most important predictors of overall well being (the other two are marriage and family satisfaction), and the distribution of job satisfaction is one of the primary concern of social sciences. Satisfaction with work climate is to be correlated in the expected direction with work behaviour. Akerlof *et al* (1988), McEvoy & Cascio (1985), and Freeman (1991) observed that work climate predicts future quits, while Clegg (1983), and Mangione & Quinn (1975) have shown that satisfaction with work climate responses are negatively correlated with absenteeism and work productivity, respectively. The understanding of this subjective well being or satisfaction, thus, provides an additional route towards the understanding of certain important labour market behaviours. Further, work climate may be as close as we are likely to come to a proxy measure of utility at work, upon which a lot of microeconomics is based.

When we look at some of the important researches related to work climate, we find that it has been conceptualized mainly in three ways: as an independent variable, as an intervening variable, and as a dependent variable. As an independent variable, one review of re-

search found that in terms of interpersonal relations, group cohesion, and task involvement, climate was significantly contributing to the job satisfaction/dissatisfaction (Hellreigel & Slocum, 1974). It was also found to be contributing to performance of the organization. That is to say, if members perceive the work climate to be supportive, then there are greater probabilities that they will feel satisfied with their jobs. Similarly, if the work environment is healthier, performance is likely to be better.

Climate as an intervening variable is usually found when human relations training or leadership have been used as the independent variable (Hellreigel & Slocum, 1974). In one study, a president's leadership style in a business game was varied and three climates were introduced: authoritarian, friendly, and achieving. The achieving condition produced the highest performance level, but the democratic – friendly conditions resulted in greater satisfaction, the authoritarian climate produced low satisfaction and low innovation and productivity (Litwin & Stringer, 1968). Other researchers looked at climate as a dependent or measurable end-result variable. Hellreigel & Slocum (1974) reviewed a number of studies that illustrated this point of view. One aggregate finding is that one's perception of climate varies according to the position held. Sensitivity-training programmes can also be responsible for changes in climate. Such programmes allow persons to try new behaviour and see themselves as other see them.

Sensitivity-training programmes can be responsible for changes in climate.

One of the major thrusts in recent organizational behaviour literature has been the contingency approach, not only for leadership, but also for climate. Thus, climate and performance and their relationship to each other are probably affected by certain other variables – technology, process development, or structure of the organization. There are, however no clear contingency factors related to climate in a universal way.

Since we are talking about action plan so as to improve work environment/climate in government departments and ministries, we should look at work climate from some other important angles also. An important variable, which should be considered in the action plan, is the gender difference in the departments. One of the most consistent findings in empirical research is a large and significant difference between men and women's perceptions on various aspects of job such as motivation, job satisfaction, and work climate (Brown, Bobko, & Hartenian, 1992; Lewis, 1991; Loprest, 1992). There is also extesive evidence that women's jobs are worse than men's in terms of job content, next promotion opportunities, and sexual harassment (Riach & Rich, 1987; Townshend, 1989). Even so, and despite higher levels of reported stress in their life, women consistently report higher motivation scores and perceive better work climate in the organization than men do (Argyle, 1989; Clark & Oswald, 1994). Women's higher motivation have been reported by Blanchflower & Oswald (1992), Blanchflower *et al* (1993), Meng (1990), and Woittiez & Theeuwes (1994). In the ensuing decade, several other researchers observed that: (i) Women were frequently omitted or under-represented as subjects, (ii) The topics studied were often more central to men's than women's lives, (iii) Women's experience were sometimes distorted by the models or methods used, and (iv) men's experiences were usually taken as the norm (Bernard, 1973; Jean & Tickamyer, 1975; Ward & Grant, 1985).

All of the above studies rely on satisfaction data being comparable across individuals: does one person use the same scale of answers to work climate questions (which in our case is on a five-point scale) as another? The answer is undoubtedly no, but if answers were purely idiosyncratic, then none of the correlation between labour market behaviour and work climate scores mentioned above would have been found. In addition, it is not clear why whole groups should systematically understand the work climate scale so differently. Lastly, psychologists and sociologists have been using such data for years and have repeatedly validated them. Their view, which is also the focus of this paper, is that there is useful information contained in cross-section answers to questions on well being, job satisfaction, motivation, and work climate.

Focus of the Study

Our effort in this research paper is purely analytical and exploratory. We have not developed any hypothesis regarding the environment in a government department or ministry. Our focus is on the following relationships/issues:

- degree of satisfaction of the government employees with various aspects of organization such as communication flow, decision-making practices, goal clarity, etc.;
- relationship of the background information of the respondents with organization-related variables;
- examination of the motivational conditions and its related factors;
- degree of satisfaction of the government

employees with various factors of group processes such as coordination, information sharing, confidence and trust;

- relationship of the background information of the respondents with various factors of group processes; and
- examination of the overall satisfaction with the group and the factors contributing to this satisfaction.

Methodology

The study was part of a larger project on "Work Climate and Job Satisfaction among Government employees". The government employees refer to staff of a department under a ministry with levels of respondents ranging from Assistant to Joint Secretary.

A questionnaire consisting of two parts was used to collect data related to work environment/climate and group processes. Before taking up the larger study, a pilot work was carried out with thirty-five employees of another department. The data obtained from the pilot work were analyzed to check the reliability of the questionnaire and also to see what type of results will emerge from the main study. Based on the results of the pilot study, a modified form of the questionnaire was developed and printed for the main study.

The sample was chosen using systematic random sampling with every third employee from the role list selected for the study. The questionnaire was distributed to the employees in small groups and the objectives, scope, outcome of the study, and the questionnaire itself was explained to them. Two days were given to the employees and from the third day onwards each respondent was contacted personally. The emphasis in these meetings was to collect reliable information and as such considerable amount of time was spent in explaining to the respondents how to fill the questionnaire.

The first part of the questionnaire was related to the work climate/environment of the department. There were nineteen questions reflecting nine factors: human resources primacy, communication flow, motivational conditions, decision-making practices, technological readiness, lower-level influence, managerial influence, union/association influence, and goal clarity. Each question was on a 5-point scale with 1 indicating satisfaction of the variable "to a very little extent" and 5 indicating level of satisfaction "to a very great extent". The second part of the questionnaire was on group processes. It contained nine questions reflecting eight factors. These are: coordination, making group decisions, knowledge of the job, information sharing, motivated to achieve objectives, and group adaptability. Here also each question was on a 5-point scale as described above. In all, 67 employees from this department participated in the study.

Analysis

For the first part of the questionnaire, i.e. questions related to work climate, means and standard deviations were calculated for the nine factors to understand the degree of satisfaction with the organization-related factors. Pearson correlations were then calculated to examine the extent of relationship between the background information of the respondents such as age, total length of service, etc. and the organization-related climate factors. Finally, for this part of the questionnaire, cluster analysis was used to determine those organizational factors that form a cluster with motivational conditions. The aim was to find out significant factors that need to be tackled along with motivation so as to get optimum level of satisfaction.

For the second part of the questionnaire, also, questions related to group processes, means and standard deviations were calculated to find out the degree of satisfaction of the government employees with their group. Pearson correlations were calculated to determine the extent of relationship between background data of the respondents and the eight factors of group processes. Finally, step-wise regression was carried out to find key factors that contribute significantly to the overall satisfaction with the work group.

Results and Observations

Table 1 presents some of the key background information of the respondents. We have covered 67 employees of this department representing different levels. Looking at the age factor, we find that a large majority of the respondents are in the age group of 40 to 50 years. And a look at the total service indicates that a sufficient number of employees have between 12 to 15 years of service. We can say, therefore, that we are dealing with a sample that is representatives of the department in the true sense and have sufficient years of experience in the government department(s). Thus, whatever conclusions we will draw from this sample, we can say with some authority that it is a representative of the work environment that is prevalent in government departments.

Table 1: Background information of the respondents (N=67)

Designation	No.	Age	Total Service
Joint Secretary/ Director	4	<40=1 40-50=2 >50=1	15 years to 33 years.
Deputy Secretary	4	<40=1 40-50=2 >5=1	11 years to 32 years.
Under Secretary/Dy. Director	22	<40=4 40-50=12 50=6	18 years to 32 years
Desk Officer/S.O.	30	<40=6 40-50=13 >50=11	(5-15) yrs-4 (16-25)yrs-13 (25-35)yrs-13
R.O.	4	<40-2 40-50=2	18 years to 20 years.
Others	3	<40-1 >50-2	16 years to 29 years.

Table 2: Means and Standard Deviations on the nine factors of Organization Climate (N=67)

Factors	Mean	S.D.
Human Resources Primacy	2.97	0.87
Communication Flow	3.03	0.75
Motivational Conditions	3.44	0.71
Decision-Making Practices	2.96	0.81
Technological Readiness	2.93	0.89
Lower level Influence	2.19	0.75
Managerial Influence	3.79	0.59
Union/Association Influence	2.13	0.79
Goal Clarity	3.79	0.90

Note: Each question was on 5-point scale.

Table 2 presents the means and standard deviations of the nine factors of organizational climate. We find that one of the highest scores is 3.79 for the factor "Goal Clarity". This indicates that for this government department, the employees are clear about what their charters and goals are. This, in a way, is a positive sign because once the goals of an organization are clear, one can think of how to achieve them. Otherwise one will remain confused about what to do, when and why. Managerial influence score is also equally high (3.79). Thus, the respondents feel that senior level employees have a say in what goes on in their department (or ministry). This factor should be seen along with what kind of influence is perceived for the lower level employees. A clear-cut bureaucratic picture emerges from these two factors with the lower level having very little influence in the departmental functioning. Even the union(s) and association(s) are perceived to be having a very low influence. Perhaps, except for the working conditions and pay packets, unions do not take much interest in organizational functioning. However, this observation of ours needs careful examination.

Motivational conditions are perceived to be satisfactory with an average score of 3.44. Our informal discussions with some employees of this department suggested that job security and good pay are two major factors contributing to this satisfaction. However, other factors of work environment may also be contributing to motivation. We will examine this point while performing the cluster analysis. For the remaining factors of organizational climate, the mean score is average i.e. near to the score of '3'. Thus, in order to increase the satisfaction with the work climate of this department, some improvement in, say, working conditions, communication flow, etc. are desirable.

Table 3 highlights significant correlations between factors of organizational climate and background information of the respondents. There are few correlations that are found to be significant. Thus, we can tentatively say that with an increase in age or total service in the government department, the work environment remains somewhat static. This is understandable as rules and regulations, hierarchical structure and value system of most of the employees remain the same. As such, no major change can be expected to take place in the functioning of the department. Does this also mean that once the goals of the ministries are spelt out, these remain the same over a period of time and, therefore, employees remain clear about the goals of the organization (Table 2) and also do not perceive major changes in achieving them? This also raises a fundamental question, that is, government employees both at the senior and lower levels are 'risk' and 'change' averters?

Table 3: Pearson Correlation between background data and nine factors of Organizational Climate (N=67)

Factors	Age	Total service
Human Resource Primacy	(+)	(+)
Communication Flow		
Motivational Conditions		
Decision-Making Practices		(+)
Technological Readiness	(-)	(-)
Lower-level Influence		(+)
Managerial Influence		
Union Influence (+)		
Goal Clarity	(+)	(+)

Note: Only significant correlation has been presented.
Figures in the brackets indicate direction of the correlation.

We now take up the significant correlation. First, we find positive relationships between age and total service,

on the one side, and working conditions and goal clarity, on the other. This indicates that with an increase in age and total service of the government employees, their satisfaction with working conditions and clarity about organizational goals goes up. We feel that these situations may hold true for the senior employees only. During our visit to the department, we found that the lower level staff are not happy with the working conditions and have little interest in organization goals. Similarly, we find positive correlations between background data (total service) and the factors, decision-making practices and managerial influence. Knowing the reality that goes on in a government office, we can observe that these correlations hold true mainly for the senior employees of the department such as deputy secretaries, joint secretaries, etc.

Lastly, from this table we find that background data are negatively correlated with the factor lower level influence. These correlations suggest that with increase in age and total service of the employees, the lower level people do not take an active part and are unhappy with what goes on in the organization. In a hierarchical organization where the bottom layer is heavy, these findings are understandable, but it raises a crucial question about the use of having such a large work force, which is located or employed, at a lower level.

Table 4 presents the results of cluster analysis carried out to know with which factors does motivation form a cluster. We find four factors of organization climate these are related to and form a cluster with motivation. These factors are: human resources primacy, communication flow, decision-making practices and union/association influence. Thus, in order to motivate the employees of this department the organization should try to improve the working conditions of the department, communication flow should be smooth, decisions should be taken in such a manner that at least those who are affected by it are involved in it, and some recognition should be given to their union or association. We feel that in a government department, working conditions can be improved. But when it comes to involving lower staff in decision-making, which is assumed to be the prerogative of seniors, the planner(s) may find it difficult to make significant changes. In some departments, we may find that junior staff are members of one or the other committee, but the roots of bureaucracy are so strong in these employees that even there they may not participate to an optimum level. Communication channels are well set in government departments with written rules and regulations. Information flows from bottom to top and decisions and directions are passed from top to bottom. Surprisingly, we find that both the groups are happy to some extent in this arrangement. During our visits we found that many a times junior staff frustrates the seniors by putting a note that a 'file is not traceable' which can take considerable time. Information, in a way, is used as powers by the junior staff as all records are maintained by them. Thus, when we talk of improving motivation level of employees of this department, one must alter the mental set-up of junior staff also.

Table 4: Motivation and its related factors: Results of Cluster Analysis.

Motivation
Human Resource Primacy
Communication Flow
Decision-making Practices
Union/Association Influence

Table 5 presents mean and standard deviations for the eight factors of group processes. The mean scores represent their levels of satisfaction on different factors of group functioning such as coordination, knowing job, motivated to achieve objectives, etc. The group which they are referring to is, most probably, the section in which they are working. We find that all the mean scores are above three, which is the mid-point or the average score on a five-point scale. Highest mean score as depicted by the table is for the factor 'confidence and trust' (4.16). This indicates that the respondents have great amount of confidence and trust in their colleagues. However, the score for the factor 'information sharing' is lowest (3.39). Interpreting the two factors, we find that confidence and trust among employees of this department does not lead to better sharing of information. In a bureaucratic organization, or for that matter any type of organization, information is seen or assumed to be a power in hand and people are not ready to share their power so easily. In a typical government department, if the information in the form of, say file, is with the concerned clerk and he puts a note 'file is not traceable', the matter can remain pending for weeks. In

Table 5: Mean and Standard Deviation on the eight factors of Group Process

Factors	Mean	S.D.
Coordination	3.67	0.85
Making group Decision	3.56	0.90
Knowing Jobs	3.56	0.85
Information Sharing	3.39	0.86
Group Adaptability	3.84	0.90
Motivated to achieve Objectives	3.75	0.94
Confidence & Trust	4.16	0.69
Overall Satisfaction	3.97	0.73

Note: Each question was on 5-point scale

fact, while studying the files of one of the projects of this department, we found this sentence quite often. Thus, in actual practice, it is difficult to say that in a government department power lies with the top bosses.

Next highest mean score is for overall satisfaction with the group (3.97). For the other factors also the mean score is quite high to indicate that the people are satisfied to a great extent with their group(s). However, while performing the stepwise regression we will find which is the most dominating factors in this satisfaction.

Table 6 present significant correlations between background information of the respondents and the eight factors of group processes. Only significant correlations are presented in the table. First, let us examine the negative correlations. The factors 'making group decisions' and 'group adaptability' are negatively correlated to age and total service. Thus, with increase in age and total service of the employees of this department, the degree of satisfaction with the way the group takes decisions and adapts to changes goes down. Further, with increase in total service, the sharing of information with colleagues also goes down. It is surprising that with increase in age and total service the amount of confidence and trust among colleagues is perceived to go up. One feels that if there exists confidence and trust among employees then they must cooperate in all respects. At this state and for these negative correlations we must see which are the factors where there does not exist any significant correlations. These are coordination, motivated to achieve objectives, and overall satisfaction. All these factors are crucial for team spirit and group functioning. We feel that the response to confidence and trust is seen more in terms of socially desirable factors rather than actual practice.

Table 6: Significant correlation between Background Data and eight factors of Group Process

Factors	Age	Total Service
Coordination		
Making group decisions	(-)	(-)
Knowing jobs	(+)	(+)
Information sharing	(-)	
Group Adaptability	(-)	(-)
Motivated to achieve Objectives		
Confidence & Trust	(+)	(+)
Overall satisfaction		

Note: Only significant correlation has been presented.
Figures in the brackets indicate direction of the correlation.

Other positive correlations are found between knowing jobs and age, and knowing jobs and total service. Thus, with increase in age and total service, the knowledge about the job also goes up. We can say that the work environment in this department is helpful for organizational learning.

Finally, Table 7 presents the results of step-wise regression. We took 'overall satisfaction' as the dependable variable and other seven factors of group processes as the independent variables. The first factor that entered the regression is 'knowing jobs'. It explains 59 per cent of variance in the overall satisfaction. The second factor in the regression is 'making group decisions'. This factor increased the R-square by 12 per cent. Lastly, the third factor that entered the regression is 'information sharing' which increase the variance by 8 per cent. The three factors together explained 79 per cent of the variation in satisfaction with the group and the remaining variance is explained by factors not covered by us. In other words, if this organization/department wishes to improve group functioning or, for that matter, wants to create effective team spirit among employees, then it should consider the three factors optimally in its action plan.

Table 7: Factors contributing to overall satisfaction with the group: results of step-wise regressions

Factors	R-sq.	R-sq. Change
Knowing jobs	0.59	-
Making group decision	0.71	0.12
Information sharing	0.79	0.08

Concluding Remarks

The main objective of the study was to understand the work environment in a government department. Work environment or climate has been seen as consisting of two parts: one related to the organizational variables and the second related to the group processes. The results of the study indicate that the government employees of this department have shown somewhat greater satisfaction with the groups in which they are working than with the organization-related factors. Lower-level influence has been perceived as low, which is understandable in a bureaucratic structure. But here we would like to mention that all information, files, records, etc. are kept with the lower level. It is, in fact, at this level that many files are prepared and moved upward. With information serving as power, we feel that the lower levels may not have influence in what goes on in the department but they have the power to hasten or slow down the movement of files and information. Many a times we noticed that on files (note sheet) it was highlighted by the lower staff that the file is not traceable. It can delay the process of clearing it by several weeks to locate that information.

An important question is when the employees are referring to a group, what exactly or, how exactly, he or she defines the group. Our informal interactions with the employees indicated that groups are based on levels in the hierarchy. Lower levels have their own group just like the senior levels. To go more in depth, we must examine the special characteristics of the government departments.

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Feature

Improved Sericulture Technologies in South India

Hiriyanna, P. Kumaresan, N.B. Vijaya Prakash & S.B. Dandin

A series of sericulture technologies were evolved in mulberry cultivation and silkworm rearing by a group of scientists. The technologies were demonstrated to a large number of farmers to estimate the yield and profitability improvement due to the technologies demonstrated and to steady the factors influencing and problems/constraints in the adoption of these technologies.

Hiriyanna, P. Kumaresan, N.B. Vijaya Prakash, and S.B. Dandin are with the Central Sericultural Research and Training Institute, Sriramapura, Mysore – 570 008, Karnataka.

Sericulture plays an important role in the economic life of man, while silk spells luxury and wealth, its production means a highly employment oriented, low capital-intensive and remunerative activity ideally suited to the labour abundant economy of India. India enjoys her position as the second largest raw silk producer in the world. During 2000-01, the country produced 15,848 MT from an area of 2.31 lakh hectares with an average silk productivity of 68.50 kg/ha.

India has gained in the production and productivity of raw silk in the last three decades due to the new technologies evolved and popularized in the field. However, there have been some constraints in the adoption of certain improved sericultural technologies, which results in variability in production. The yield levels realized by the farmers tend to be lower than those recorded in research stations leaving considerable untapped yield potential. Therefore, a need arises to probe into the factors responsible for lack of technology adoption and variability in the production. Once the factors are identified, it is possible to reduce the income inequalities across the region and groups of farmers. One of the factors deciding the acceptance and sustenance of new technologies is its economic viability over the existing technology. In this backdrop, a study on the impact of technology demonstration would provide feedback to the scientists regarding the performance of technology at the field level and help the policy makers and extension workers in delineating the areas which require the attention of the extension workers for effective dissemination of technologies and to minimize the gap existing between lab and land.

Background of the Study

Because of the efforts of the scientists of the Central Sericultural Research and Training Institute (CSRTI), Mysore, a series of improved sericulture technologies were evolved in mulberry cultivation and silkworm rear-

ing during the 1990s. After conducting field trials at research stations under different agro-climatic conditions, the technologies were demonstrated to a large number of farmers under group demonstration programmes by nested units of CSRTI, Mysore, namely, Research Extension Centers (RECs) and Sub-units of RECs.

The group demonstration programme was initiated during 1998-99. As per the programme, each REC conducted five group demonstrations per year covering 100 farmers at the rate of 20 farmers per group. The newly developed mulberry cultivation and silkworm rearing technologies were demonstrated with the lead farmer identified for each group. The other participant farmers were expected to observe the results of technologies demonstrated and practice them for their yield improvement. The farmers whose average yield was not more than 35 kgs/100 dfls were selected for group demonstrations with the target of reaching their yield level to 50 kgs/100 dfls at the end of the programme.

In this context, a comprehensive study has been taken up to analyze the impact of technologies demonstrated with the farmers on yield and profitability improvements and the factors influencing the technology adoption with the following specific objectives:

- To estimate the yield and profitability improvement due to adoption of the technologies demonstrated;
- To study the factors influencing the technology adoption; and
- To study the problems/constraints in adoption of technologies demonstrated.

Methodology

The group demonstrations have been conducted in eight RECs and seven sub-units of RECs in three major sericulture states namely Karnataka, Andhra Pradesh and Tamil Nadu. REC, Madivala in Karnataka, REC, Rayachoty in Andhra Pradesh and REC, Krishnagiri in Tamil Nadu were purposively selected for the study. The staff involved in group demonstrations and 50 randomly selected farmers were interviewed with a pre-designed interview schedule in each REC. Thus, the total sample size constituted 150 farmers. The information regarding the details of socio-economic conditions, level and costs of inputs used, yield levels, price obtained for cocoons, knowledge level of different technologies, adoption rate of technologies and problems in adoption of technologies, were collected from the farmers. The collected data were tabulated and subjected to statistical analyses.

Analytical framework

Adoption coefficient was worked out to study the impact of socio-economic factors on the adoption of different sericultural practices demonstrated to farmers by RECs. For this purpose, full adoption was scored as 2, partial adoption as 1 and non- adoption as 0 for each technology and the total score (actual score) was worked out for each farmer based on the level of adoption of the technologies or practices recommended by RECs under the group demonstration programme. Then the adoption coefficient was computed for each farmer by using the following formula:

$$\text{Adoption coefficient} = \frac{\text{Actual score obtained}}{\text{Total score obtainable}} \times 100$$

Multiple regression model was chosen over other forms to evaluate the factors influencing the adoption of improved sericultural practices. The adoption coefficient was considered as the dependent variable and regressed with the socio-economic factors as follows in the model chosen for the study.

$$Y = \sum_{i=1}^{6} b_i X_{i\mu}$$

Where

Y = Adoption coefficient

X_1 = Age (number of years)

X_2 = Education (score)

X_3 = Extension participation (score)

X_4 = Extension contact (score)

X_5 = Mass media participation (score)

X_6 = Group (dummy)

Partial budgeting technique was used to estimate the net gain due to adoption of improved practices demonstrated in place of traditional/regular practice.

Results and Discussion

Under the group demonstration programme, RECs demonstrated the important mulberry cultivation technologies developed by CSRTI, Mysore, namely, maintenance of separate mulberry garden for young age silkworm larvae, vermi-composting, application of azatobacter, triacontonal spray and integrated pest management (IPM) of mealy bug and sericulture technologies, namely, wrap-up method of young age silkworm rearing, disinfection with bleaching powder and chlorine dioxide, application of Vijetha, IPM of uzifly

and use of raksha rekha as a package along with other regular practices. The brief details of the technologies are given in Appendix I. The impact of the demonstrations in each REC was studied and the results are discussed.

Productivity performance of technologies demonstrated by RECs

The results of mulberry and cocoon yield improvement due to the adoption of technologies demonstrated by RECs are presented in Table 1. Significant variability in both mulberry as well as cocoon yield levels could be observed between, before and after demonstrations in all the three RECs. The mulberry leaf yield improvement was ranging from 11.32% in REC, Krishnagiri to 23.78% in REC, Rayachoty. The cocoon yield improvement due to the adoption of technologies was more significant compared to mulberry yield improvement in all the three RECs. In REC, Rayachoty, farmers realized 64.12% improvement in cocoon yield followed by 41.67% by the farmers of REC Madivala and 40.50% by the farmers of REC Krishnagiri. The before demonstration and after demonstration yield levels of REC, Krishnagiri, was less for both mulberry leaf and cocoon production. This was due to the small-scale production and possession of less facilities such as rearing house and rearing appliances by the adopted farmers of REC, Krishnagiri, compared to the other two centres.

Table 1: Impact of group demonstrations conducted by RECs

Sl. No	Name of the Centre	Yield		Improvement (%)
		Before demonstration	After demonstration	
I	Mulberry yield (kg/acre)			
1	REC Madivala	11664.00	13279.20	13.85
2	REC Rayachoty	9135.20	11307.20	23.78
3	REC Krishnagiri	7159.35	7630.01	11.32
II	Cocoon yield (kg/100 dfls)			
1	REC Madivala	38.49	54.53	41.67
2	REC Rayachoty	33.75	55.39	64.12
3	REC Krishnagiri	33.76	47.43	40.50

Economic performance of technologies demonstrated by RECs

Partial budgeting technique was used to analyze the additional net profit earned due to adoption of technologies demonstrated to the farmers. The additional costs incurred on farm yard manure, fertilizers, disinfectants, vijetha and labour were substantial in all the three RECs, whereas the costs incurred on the azatobacter, uzitrap and raksha rekha were less as adoption rate of these technologies were relatively low. Though application of FYM and fertilizers were not part of the group demonstration programme, as the extension workers frequently visited the adopted farmers and provided continuous technical guidance, the rate of consumption of fertilizers and FYM, which are important for yield and quality improvement, increased. The increase in the expenditures on disinfectants and vijetha might be the reason for increased crop stability and additional cocoon yield with the farmers. Though many labour saving technologies such as shoot rearing were demonstrated to the farmers, the labour input usage was increased due to the increase in mulberry leaf production and thereby, increase in size of rearing each time.

The comparison of the structure of additional costs and returns of three RECs shows that the costs incurred on different inputs by REC, Krishnagiri, was less with Rs. 3692.24 compared to Rs. 4653.17 in REC, Madivala and Rs. 4619.93 in REC, Rayachoty. The return from the additional cocoon was more with Rs. 24375.04 in REC, Madivala, followed by Rs. 23559.90 in REC, Rayachoty and Rs.11580.07 in REC, Krishnagiri. The net gain due to the adoption of technologies demonstrated ranged from Rs.7887.83/acre/year in REC, Krishnagiri to Rs. 19721.87/acre/year in REC, Madivala. The less net gain in returns by the sample farmers of REC, Krishnagiri, was due to less yield improvement and less price fetched for their cocoon compared to the other two RECs.

Factors influencing improved sericulture technologies

A multiple regression model was fitted to study the impact of socio-economic factors on adoption of different rainfed sericultural practices. For this purpose, the adoption coefficient was considered as the dependent variable and regressed with the socio-economic factors such as age, education level, extension participation, extension contact, mass media participation and group. The estimated values of regression coefficients are presented in Table 3. It may be seen from the table that the values of coefficient of multiple determination (R) were reasonably good in all the cases. The regression coefficients of extension contact were positive and statistically significant for REC, Madivala and REC, Rayachoty but not for REC, Krishnagiri. This

Table 2: Economic impact of group demonstrations conducted by RECs

Sl. No.	Particulars	Amount (Rs.)		
		REC, Madivala	REC, Rayachoty	REC, Krishnagiri
I	Debit			
A	**Increase in cost/acre/year**			
a	FYM	1405.42	1306.28	1064.29
b	Fertilizers	1204.64	1154.50	916.00
c	Azatobactor	20.10	18.16	19.91
b	Disinfectants	725.55	661.54	607.13
e	Vijetha	522.00	598.27	415.80
f	Uzitrap	21.78	15.24	16.00
g	Raksha rekha	5.12	5.48	3.00
H	Labour	748.56	860.46	650.12
B	Decrease in returns/acre/year	0.00	0.00	0.00
	Total	4653.17	**4619.93**	**3692.24**
II	**Credit**			
A	**Increase in returns/acre/year**			
	Return from increased cocoon production	24375.04	23559.90	11580.07
B	Decrease in cost/acre/year	0.00	0.00	0.00
	Total	**24375.04**	**23559.90**	**11580.07**
	Net gain/acre/year (II - I)	**19721.87**	**18939.97**	**7887.83**

implies that the adoption rate was high with the farmers having more contact with the extension agencies such as REC, Department of Sericulture, and progressive farmers. Extension participation was positively significant with adoption coefficient for REC, Krishnagiri, which implies that more participation of farmers in extension programmes conducted by REC or Department of sericulture in demonstrations, field days, group discussions etc led to improved sericulture technologies. The extension participation did not have any significant association with the dependent variable for the other two RECs.

The regression coefficients were positive and significant with respect to education in case of REC, Madivala and REC, Krishnagiri. But the regression coefficient was not significant for REC, Rayachoty. The demonstrations were conducted for groups of farmers, normally 20 farmers per group. The interaction within the group or with the extension worker, who conducts

Table 3: Regression coefficients of factors influencing the adoption of improved sericultural practices

Parameters	Regression coefficients		
	REC, Madivala	REC, Rayachoty	REC, Krishnagiri
Constant	11.240	13.153	8.929
Extension participation	-0.170	0.836	0.384
	(0.675)	(1.255)	(0.096*)
Extension contact	2.324	1.271	-0.009
	(0.995*)	(0.753**)	(0.408)
Mass media participation	0.321	-1.433	-0.201
	(0.892)	(1.703)	(0.351)
Age	0.094	0.097	-0.007
	(0.155)	(0.105)	(0.032)
Education level	2.767	0.303	0.862
	(1.244*)	(1.272)	(0.325*)
Group (dummy)	-0.349	-3.219	-2.554
	(0.777)	(1.653**)	(0.421*)
R^2	0.496	0.542	0.699

Note: * - Significant at 1.00 per cent level
** - Significant at 5.00 per cent level

the demonstration, may impact on the adoption of the technologies demonstrated. Hence, dummies (such as 1, 2 and 3) were provided for each group and included as one of the variables. The regression coefficient of group dummy was significant for REC, Rayachoty and REC, Krishnagiri but not for REC, Madivala. This indicates that group interaction plays a very important role in technology adoption. The regression coefficients of age and mass media participation did not have any significant relationship with adoption for any REC.

Pattern of adoption and constraints in adoption of technologies

The adoption pattern of technologies demonstrated by REC Madivala, Rayachoty and Krishnagiri is shown in Table 4. The adoption rate of mulberry gardens for young age silkworm larvae, vermi-composting, triacontonal spray, wrap-up method of young age silkworm larvae and raksha rekha was very less with the majority of the farmers. As majority of the farmers in REC Madivala area obtained young age silkworm larvae from Young age silkworm Rearing Centres, they did not maintain a separate mulberry garden for young age silkworm larvae. The major reason given by the farmers of REC Rayachoty and REC Krishnagiri for not owning a separate garden was preference for the traditional practice of using the leaf of late age garden for young age silkworm rearing. The farmers of REC Madivala and Rayachoty expressed that vermi-composting was a cumbersome and more

Table 4: Adoption pattern of technologies demonstrated by REC,Madivala, Rayachoty and Krishnagiri

(Figures are in %)

Particulars	REC, Madivala			REC, Rayachoty			REC, Krishnagiri		
	Full	Partial	No	Full	Partial	No	Full	Partial	No
Mulberry garden for young age silkworm larvae	0.00	32.00	68.00	0.00	8.00	92.00	0.00	21.15	78.85
Vermi composting	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
Azatobacter application	4.00	62.00	34.00	0.00	72.00	28.00	3.85	23.08	73.08
Triacontonol spray	0.00	22.00	78.00	0.00	2.00	98.00	0.00	3.85	96.15
IPM of mealy bug	0.00	64.00	36.00	0.00	78.00	22.00	0.00	26.92	73.08
Shoot rearing	24.00	40.00	36.00	0.00	2.00	98.00	1.92	3.85	94.23
Disinfection with bleaching powder	76.00	24.00	0.00	68.00	32.00	0.00	44.23	48.08	7.69
Disinfection with Chlorine dioxide	12.00	54.00	34.00	0.00	72.00	28.00	11.54	40.38	48.08
Wrap-up method of young age silkworm rearing	0.00	0.00	100.00	0.00	0.00	100.00	28.85	0.00	71.15
Vijetha	16.00	62.00	22.00	18.00	78.00	4.00	0.00	65.38	34.62
IPM of uzifly	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00	0.00
Raksha rekha	2.00	4.00	94.00	0.00	2.00	98.00	5.77	0.00	94.23

labour intensive technology. On the other hand, availability of a sufficient quantity of farmyard manure did not force the farmers of Krishnagiri to adopt the vermi-composting technology. The major reason expressed by the farmers for not adopting triacontonal spray was not realizing the benefit of the technology. Wrap-up method of young age silkworm rearing was not popular with the farmers as majority of the farmers were not aware about the method and preferred traditional practice of young age silkworm rearing. More than 80% of the farmers in all the RECs used alternative practices of grease, turmeric powder, BHC and DDT powder, in place of raksha rekha for controlling ants in silkworm rearing houses.

The technology adoption was partial for application of azatobacter, IPM of mealy bug, disinfection with chlorine dioxide, vijetha and IPM of uzifly. Integrated management practices of manual clipping of the pest affected portions of the mulberry plant, release of bio-control agents in the field and chemical spray were demonstrated for the effective control of mealy bug in mulberry gardens. However, majority of the farmers felt that using the chemicals spray was not economical for controlling the mealy bug incidence in a mulberry garden. Majority of the farmers did not prefer the alternative disinfectant, chlorine dioxide, as the chemical was expensive compared to bleaching powder. Vijetha was either fully or partially adopted by all the farmers. However, the farmers expressed that Vijetha was expensive. The farmers of REC, Kolar, preferred other chemicals as a bed-disinfectant instead of Vijetha, as different bed disinfectant chemicals were available in the area. The integrated practices, which include mechanical control of using a nylon net to prevent the entry of uzifly, bio-control agents to parasatize uzi larva and uzitrap to attract and kill the flies were demonstrated to control the uzifly. The farmers felt that the traditional practice of using nylon net and wire mesh was effective for controlling the uzi fly. About 60% of the farmers expressed that uzitrap was not effective in controlling the uzifly.

Above 80% of the farmers in all the RECs used alternative practices of grease, turmeric powder, BHC and DDT powder, in place of raksha rekha for controlling ants.

The disinfection with bleaching powder was adopted by the majority of the farmers in all the RECs. However, the farmers were of the opinion that bleaching powder was corrosive and injurious to health. The adoption rate of shoot rearing was comparatively more in REC Madivala but not popular in the other two RECs, as shoot rearing requires more space in the rearing house.

Summary and Conclusion

The study was conducted to analyze the impact of technologies demonstrated by RECs with the farmers on yield and profitability improvements and the factors in-

fluencing technology adoption. The data were collected from the randomly selected 50 farmers participating in the group demonstrations in each REC, Madivala, Rayachoty and Krishnagiri. The results indicated that though the adoption of improved technologies was less for some technologies, there was significant yield and profitability improvement due to the group demonstration programme. The major reason for this may be continuous technical guidance provided to the farmers by the REC staff under the programme and use of more inputs such as fertilizers, farm yard manure and disinfectants, which helped more yield and higher crop stability.

The regression analysis indicated that extension contact and group activities played an important role in adoption of improved sericulture technologies. A detailed analysis of the groups in which the rate of adoption of technologies was high would provide a picture on the factors leading to the success of group demonstration.

Many of the eco-friendly and cost-saving improved practices such as application of azatobacter and vermi-composting, triacontonol spray, IPM of mealy bug, shoot rearing, wrap-up method and raksha rekha, were not accepted by the farmers. Participatory research may be conducted with the farmers for refining the technologies to suit the needs of the farmers.

Appendix I

Details of Technologies Demonstrated Under Group Demonstration Programme of RECs

I. Mulberry cultivation technologies

1. *Maintenance of a separate mulberry garden for young age silkworm larvae*: Young age silkworm larvae require soft and succulent leaves, which are rich in water, protein, carbohydrate and mineral content. Hence, a separate garden with a specific package of practices are recommended for young age silkworm larvae against the traditional practice of using the leaf from the same garden for young as well as late age rearings.
2. *Vermi-composting*: Vermi-composting is a technique to use earthworms for converting the sericultural wastes into nutrient rich compost within 50-60 days so that the wastes can be recycled. The conventional method of composting requires 4-5 months.
3. *Application of azatobacter*: Azatobacter is a bacterial bio-fertilizer, which fixes nitrogen thereby saving the application of 50% of chemical nitrogenous fertilizers.
4. *Triacontonal spray*: Triacontonal is a growth regulator. The studies indicated that spraying Triacontonal improves the mulberry leaf yield by 15-20% in addition to significant improvement in leaf quality.
5. *Integrated pest management (IPM) of mealy bug*: Mealy bug is a serious pest causing damage to leaf yield and quality in mulberry gardens. The integrated measures for the control of mealy bug include mechanical methods of removal and destruction of infected parts of the mulberry; biological method of release of bio-control agents, *Cryptolaemus montrouzieri*, and chemical method of spraying chemicals for controlling the pest. The integrated method is more effective, eco-friendly and economical.

II. Silkworm rearing technologies

1. *Wrap-up method of young age silkworm rearing*: Wrap-up method is a simple and effective method which helps to improve the rearing bed humidity by 15-20 % thereby keeping the moisture content of the mulberry leaf for a longer duration. The field testing of this technology revealed 5-7 kg improvement in cocoon yield per 100 dfls.
2. *Disinfection with bleaching powder*: As silkworms are highly domesticated, they are susceptible to diseases. As cure of silkworm diseases is uneconomical and impractical, it is suggested we disinfect the rearing houses and appliances before taking up rearing. 2% bleaching powder solution is recommended as disinfectant in place of formalin, which is effective only for a closed type of rearing and is highly injurious to the health of human beings.
3. *Disinfection with chlorine dioxide:* 2.5% chlorine di-oxide solution is recommended for disinfection of rearing houses and appliances, as it is more stable and less corrosive.
4. *Application of Vijetha:* Vijetha is a silkworm body and silkworm disinfectant for the prevention of silkworm diseases. It is used at the time of silkworm rearing and is effective in the prevention of diseases.
5. *IPM of uzifly:* Uzifly is a serious pest, which causes 10-20% crop loss. The integrated control measures include creating a physical barrier using a nylon net or wire mesh to prevent the entry of the fly; spraying the chemical (uzicide); releasing the bio-control agent, *Nesolynx thymus*, and using the uzitap, a chemo-trap to attract and kill the adult flies.
6. *Use of raksha rekha:* Raksha rekha is a chalk dipped with insecticide. Drawing lines using this chalk can prevent the attack of insects such as ants and cockroach on silkworm.

□

You can't use up creativity. The more you use, the more you have.

– Maya Angelou

Feature

Economic Efficiency of Milk Production in Tamil Nadu

B. Ganesh Kumar & Raj Vir Singh

This article analysis the input-output relationship, productivity of inputs and resource use efficiency of milk production for local and crossbred cows using production function analysis under rural conditions in Tamil Nadu. This is done to enable farmers to make the desirable adjustments at the farm level to maximize profits.

B. Ganesh Kumar is Scientist, Central Agricultural Research Institute, Port Blair-744 101, Andaman and Nicobar Islands. Raj Vir Singh is Principal Scientist and Head, Division of Dairy Economics, Statistics & Management, National Dairy Research Institute, Karnal-132 001, Haryana.

Milk production is a complex biological phenomenon controlled by a number of factors. The milch animal is just like a biological machine converting roughage and crude protein into milk. The milk conversion process is however, controlled by genetic and non-genetic factors. Type of breed and ability of milk secretion by individual animals are the important genetic agents. The non-genetic factors influencing milk production are type and quantity of feeds fed, stage and order of lactation, herd size, quality of management and climatic conditions, etc. The most important inputs in milk production are green fodder, dry fodder and concentrates. These resources which are scarce have to be optimally utilized on the basis of their marginal productivity. The knowledge of various inputs and their productivity is of considerable importance for making desirable adjustments at the farm level in order to maximize profit. The present study is an attempt to analyze the input-output relationship, productivity of inputs and resource use efficiency of milk production for local and crossbred cows using production function analysis under rural conditions in Tamil Nadu.

Materials and Methods

Sampling plan and Data collection

Commensurate with the objectives of the study, Villupuram district was purposively selected mainly because it had the highest number of cattle among all the districts in the state (Annual Administrative Report, Department of Animal Husbandry, Government of Tamil Nadu, 1994-95), indicating thereby a great potential for scientific dairy farming and a suitable background for such a study.

A four stage stratified random sampling design was used for collecting the data with division, block, village

and farm households as the first, second, third and fourth stage, respectively. Altogether 90 sample households were randomly selected using simple random sampling without replacement.

The input data such as green fodder, dry fodder, concentrates, human labour (both family and hired), veterinary expenses and other miscellaneous expenses and inventory comprising milch animals, cattle shed, stores, dairy and watering equipments, etc. and the output data such as milk and dung were collected from selected households by survey method on well designed and pretested interview schedules by making personal visits to each household to meet the requirements of the objectives of this study. The collected data pertained to the agricultural year 1996-97.

Production function analysis

Production function analysis was used to find out the input-output relationship, marginal value productivity of inputs used and also to examine the resource use efficiency in milk production for both local and crossbred cattle. The milk production function refers to the technical relationship between inputs like green fodder, dry fodder, concentrate, etc. and output of milk. It provides the information on expected variation in the amount of milk when certain quantities of inputs are changed in the production. Since individual milk producers used different types of feeds, it was not possible to transform these inputs into standard comparable inputs. However, the price of each input indirectly reflects the quality of feed input. It was, therefore, considered appropriate to express these inputs in value terms instead of physical terms. Hence, expenditure on green fodder, dry fodder and concentrates formed the main explanatory variables together with that on labour which can be taken crudely as a proxy for management input, while milk production in value terms for individual animals was the dependent variable. Evidences from many previous studies also have indicated that Cobb-Douglas function is the most appropriate form of production function in the field of agriculture and dairying (Pandey and Kumar, 1981; Balishter *et al*, 1985; Tripathi *et al*, 1986; Sharma and Singh, 1993).

For the present study, Cobb-Douglas production function can be written as:

$$Y = a X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} e^u$$

In log linear form the above function can be written as:

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + u$$

Where,

Y = Value of milk produced per cow per day (Rs.)

X_1 = Value of green fodder fed per cow per day (Rs.)

X_2 = Value of dry fodder fed per cow per day (Rs.)

X_3 = Value of concentrate fed per cow per day (Rs.)

X_4 = Value of human labour (both family and hired) used per cow per day (Rs.)

a = Constant

b_1, b_2, b_3 and b_4 = Regression coefficients or production elasticities of the respective inputs.

Estimation of Marginal Value Product (MVP)

Marginal value of a particular input is calculated by taking the first order partial derivative of the output (Y) function with respect to its corresponding input (X_i). In case of Cobb-Douglas production function, since regression coefficients of inputs give their respective production elasticities, MPP of all the inputs can be calculated by the formula as given below:

$$MPP_{xi} = \left(\hat{b}_i \frac{\bar{Y}}{\bar{X}_i} \right)$$

Where,

$\bar{Y}$ = Geometric mean of milk yield,

$\bar{X}_i$ = geometric mean of i^{th} input,

$\hat{b}_i$ = Regression coefficient of i^{th} input, and

i = 1, 2, 3 and 4.

Resource use efficiency

Resource use efficiency comprised the distribution of a given amount of scarce factor among a set of alternatives in the production so as to maximize the relevant end of the economic unit in question. In order to study the resource use efficiency of an input, marginal value productivity (MVP) of each input was found and compared with its acquisition cost or unit price of concerned input. The input is said to be overutilized if $(MVPx_i - Px_i) < 0$ and hence to increase profit, it is recommended to decrease the use of that input. But, if $(MVPx_i - Px_i) > 0$, it is advised to increase the use of X_i resource to get higher economic returns as in this case

the input is said to be underutilized. Using t-test, the formula for which is given below, the significant difference between MVP and unit price of input was tested.

$$t = \frac{MVP_{xi} - P_{xi}}{SE\,(MVP_{xi})}$$

$$SE(MVP_{xi}) = SE(b_i)\,\frac{\bar{Y}}{\bar{X}_i}$$

Where,

MVP_{xi} = Marginal value productivity of X_i resource,

P_{xi} = Price per unit of X_i resource and

$SE(b_i)$ = Standard error of regression coefficient associated with X_i resource.

The absolute value of calculated 't' was compared with table value of 't' in case of all input at (n-k-l) degrees of freedom where 'n' is the total number of observations and 'k' is the total number of explanatory variables. If calculated 't' is less than table value of 't', it is concluded that the difference between MVP of a resource and its acquisition unit price was statistically insignificant indicating the optimal use of this resource and vice versa.

Results and Discussion

Input-Output relationship

Milk Production function describes input-output relationship in milk production. Milk production function in case of both local and crossbred cows was fitted and the results of regression analysis are presented in Table 1. The estimated Cobb-Douglas function explained about 72 and 70 per cent of variation in returns from milk yield of local and crossbred cows, respectively. Pandey *et al.* (1980) found that 40-85 per cent of the variation in milk yield was due to fodder, concentrates, labour and other expenditure. It is further observed from the table that three variables, namely, expenditures on dry fodder, concentrates and labour were having positively significant impact, while expenditure on green fodder had positive but non-significant impact on returns in milk production from local cows. This indicated that returns could be increased by increasing the level of use of dry fodder, concentrate and labour in the milk production process.

However, in case of milk production from crossbred cows, it can be observed from the table that expenditures on dry fodder and concentrates had positive and significant impact, while those on green fodder and labour were found to have positive but non-significant impact on return from crossbred cow milk production. This indicated that feeding more dry fodder and concentrates to the crossbred cows could increase revenue. Wani *et al.* (1992) also suggested that net income could be increased by higher level of use of concentrates and roughages.

Table 1: Milk Production Function (Cobb-Douglas) for Milch Animal

Particulars	Local cows	Crossbred cows
No. of observations	69	175
Constant	2.885	2.017
Expenditure on green fodder	0.0054 (0.0152)	0.0082 (0.0156)
Expenditure on dry fodder	0.0258*** (0.0097)	0.4281*** (0.1261)
Expenditure on concentrates	0.0344*** (0.0112)	0.2771*** (0.0509)
Expenditure on labour	0.8214*** (0.2015)	0.1349 (0.3010)
Coefficient of multiple determination	0.72	0.70

Figures in the parentheses are standard errors of regression coefficients.

***Significant at 1 per cent level

Feeding more dry fodder and concentrates to the crossbred cows could increase revenue.

One thing that appears to be surprising is that green fodder, an important dairy input, turned out to be non-significant in milk production for both local and crossbred cows. This may be because of insignificant variation in feeding of this input to the animal by the farmers of the study area.

Resource productivity and resource use efficiency

The ratio of MVP to factor prices provides a measure of resource allocative efficiency. In order to determine the direction in which a resource should be used, this ratio was compared with unity. If the ratio is one, it suggests that the resource is being used optimally. A greater than one ratio indicates that there is possibility of increasing the resource under consideration both to increase productivity and profitability. A ratio of less than one indicates that resources could be reduced without any detrimental effect on production and profitability.

Marginal value products (MVP) of inputs in milk production from both local and crossbred cows are

Dry fodder use was excessive and labour use was deficient on indigenous cows.

presented in Table 2. A perusal of the table reveals that in case of milk production from local cows, the MVPs of two inputs, viz. dry fodder and concentrates, were significantly less than unity, signifying overutilization of these inputs; while that of labour was observed to be significantly more than unity indicating its underutilization. Similarly, Lalwani (1990) also found that dry fodder use was excessive and labour use was deficient on indigenous cows. This calls for reduction in feeding of dry fodder and concentrate and increase in the use of labour in order to increase productivity and returns from local cow milk production. However, the MVP of green fodder was found to be statistically not different from unity, indicating its optimal feeding to local cows.

Table 2: Marginal Value Products of Inputs for Milch Animal.

(Rs.)

Inputs	Local cows	Crossbred cows
Green fodder	0.2948 (0.8299)	0.5540 (1.0539)
Dry fodder	0.4295*** (0.1615)	9.8636*** (2.9054)
Concentrates	0.3787*** (0.1233)	3.1378*** (0.5764)
Labour	4.1993*** (1.0301)	0.9145 (2.0405)

Figures in the parentheses are standard errors of marginal value products of inputs.

***Significantly different from unity at 1 per cent level.

In case of milk production from crossbred cows, it is apparent from the table that MVPs of two inputs, viz. dry fodder and concentrates, were significantly greater than unity, indicating thereby their underutilization in the milk production process. Kumar and Agarwal (1994) also found that the MVP of concentrates was positive and significantly greater than unity for cows, indicating their underutilization in the milk production process. Kumar and Agarwal (1994) also found that the MVP of concentrates was positive and significantly greater than unity for cows, indicating their underutilization. In another study, Sharma and Rajpali (1989) found that dry fodder was underutilized in urban dairy units. This indicates that crossbred cows should be fed more dry fodder and concentrates in order to increase return from milk production. However, the MVPs of green fodder and labour turned out to be statistically not different from unity signifying optimal use of these inputs.

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Before it can be solved, a problem must be clearly defined.

– William Feather

Feature

Policy Options for the Dairy Sector

P.S. Khattra, Jagjit Singh & Ravinder Singh Harika

This study was conducted in Amritsar district of Punjab covering three distinct situations, urban, semi-urban and rural. The break-even levels of milk production per dairy farm and per standard animal unit in urban areas were found to be more sensitive to the fluctuations of milk price. The optimality criteria suggested that curtailment in the use of green fodder in a rural situation and augmentation in the intensity of feeding inputs in all other situations can go a long way to improve profitability from dairying. The price elasticity of milk supply was found to be the highest in the rural situation and it was followed by semi-urban and urban situations. The milk supply was found to be more sensitive to price of green fodder in urban areas, to the price of dry fodder and concentrates in the rural area.

P.S. Khattra, Jagjit Singh and Ravinder Singh Harika are Professor of Agricul.tural Economics, Research Scholar and Research Fellow, respectively, in the Department of Economics, Punjab Agricultural University, Ludhiana-141004.

Farming in Punjab has been facing a financial crisis mainly due to cost price squeeze, stagnation in productivity of major crops and increasing number of uneconomic holdings resulting from a rapid increase in population. The sustainability of farming is also of serious concern due to the falling water table, depletion of micronutrients from the soil and higher incidences of plant diseases and pestilence. The diversification of crop farming with dairy enterprise can go a long way to mitigate the problem of poverty, especially of marginal and small farmers. Mixed farming where dairy animals can utilize crop residues, cereals and oilseeds milling by-products, along with some cultivated fodder, on one hand, and improving the soil health by supplying organic manure on the other, may be economically and ecologically a better alternative to crop farming. Thus, there is a strong inter dependence between crop farming and dairying. Moreover, dairying is a source of regular income and also helps reduce disguised unemployment in agriculture because of its labour intensive nature. The milk production in India increased marginally with a less than one per cent growth rate from 1950-51 to 1970-71. The development of organized milk marketing infrastructure with successful implementation of Operation Flood helped improve rural-urban linkages, which in turn, enhanced the milk production at a higher annual compound growth rate of 4.6 per cent during the period from 1970-71 to 1980-81. The highest annual compound growth rate of 5.5 per cent in the production of milk was recorded in the decade from 1980-81 to 1990-91 and it came down to 4.4 per cent at present. In order to safeguard the economic interest of dairy farmers and to keep the dairy economy on the fast trajectory of economic growth, it is important to make optimal adjustments in the resource mix of dairy enterprises due to continuously changing input-output prices. Such adjustments require critical appraisal of the existing resource mix in the light of marginal productivity analysis. The precise information on price supply responsiveness of milk will be of immense utility for the policy makers in their endeavour to formulate a realistic milk price policy for achieving a higher level of milk supply.

It is also pertinent to determine the levels of milk output per dairy farm and per standard animal unit at which total revenue just covers the total costs by means of cost-volume profit relationship. This analysis is also commonly known as break-even analysis, indicating the level of output at which total revenue breaks even with total cost i.e. a point of no profit and no loss. This technique determines the minimum level of milk output at which the dairy farm business just starts earning profit. The utility of this technique was further enhanced by studying the sensitivity of profit from dairying to the changes in the input-output prices. The break-even analysis has been conducted to provide useful information in terms of milk per standard animal unit and per dairy farm.

Several studies conducted in the past pertaining to dairy development in different parts of the country remained confined to the budgeting of costs and returns, appraisal of existing resource use patterns and projections of milk production. Some such studies (Jacob *et al,* 1971; Rao, 1985; Sharma *et al,* 1987; Wani *et al,* 1992; Shah *et al,* 1995; Venkatasubramanian and Fulezele, 1996; Khattra *et al,* 2002; and Khattra and Harika, 2002) are worth mentioning. Despite the immense practical utility of break-even analysis, sensitivity analysis and analysis of milk supply functions, the research work in these areas has been relegated to a place of lower importance. Some sporadic research work conducted using break-even analysis and milk supply functions was found to be too location specific and period specific to be generalized. The present study is, therefore, an attempt to fill this important void in literature on dairy research.

Specifically, the main objectives of the study were:

- To determine break-even quantities of milk per animal and per dairy farm under different situations and to study their sensitivity to milk prices.
- To appraise the existing use of feeding inputs for suggesting ameliorative measures.
- To derive milk supply functions and to document the gaps between existing and optimum productivity of milch animals.

Methodology

The study is purposely conducted in Amritsar district as the dairy enterprise has been well incorporated in the production programmes of the farmers due to the establishment of milk cooperative societies under Punjab State Dairy Development Board in the study area. Moreover, no such study had earlier been undertaken in this area.

Amritsar block was also purposely selected as it represented the maximum number of milch animals as well as maximum contribution in the production of milk among all the blocks of this district. The milk production activity is being carried out in three distinct situations, urban, semi-urban and rural. The villages falling within 10 km from the periphery of the city represented the semi-urban area and the villages beyond 10 km from the periphery of the main city but not closer than 5 km from other towns of the district were classified as rural areas.

The lists of villages representing semi-urban and rural areas of the selected block were prepared separately. The total numbers of villages in the semi-urban and rural locations were 98 and 281, respectively. Among the total number of villages in the semi-urban and rural locations from the selected block, three per cent of villages i.e. three villages from semi-urban and eight villages from rural situations, were selected randomly without replacement.

For the selection of dairy farms in the urban area, the list procured from the office of Municipal Corporation, Amritsar, showed a large variation in the number and size of dairies in different localities. Therefore, the city localities were stratified into three categories representing low, medium and high concentration of dairies in the locality. The colonies with less than 20 dairies were put under low concentration category, the colonies with 21-40 dairies were put under medium concentration category and the colonies with more than 40 dairies were put under high concentration category. Ten per cent of the total number of colonies from each category was selected randomly without replacement as given in Table 1.

Table 1: Selection of dairy colonies

Concentration of dairies	Total number of colonies	Number of selected colonies
Low (≤ = 20 dairies)	42	4
Medium (21-40 dairies)	16	2
High (<40 dairies)	11	1

There were 137 dairy farms in the sampled urban colonies, 653 in the semi-urban villages and 1273 in the rural sampled villages. The corresponding total milch cattle in these sampled locations were 2958, 3660 and 4546 in urban, semi-urban and rural situations, respectively. All the dairy farm units of each location were arranged in ascending order on the basis of milch animals maintained. Then these dairy units were stratified into three herd size categories, namely, small, medium and large, by using cumulative cube-root frequency method. From these, a sample of 102 dairy farms was randomly selected from different situations in such a manner that

the numbers of dairies in different situations were in proportion to the numbers of milch cattle in these situations. Further, the dairy farms in each situation were allocated among different size categories in proportion to the number of dairy farms in that category. The main features of selected dairy farms are summarized in Table 2.

Table 2: Characteristics of sample dairy farms

Situation	Sample location/ villages		Category	Herd Size (No.)	No. of dairies	
	No. of location/ villages	No. of milch cattle			Total	Sampled
Urban	7	2958	Small	≤ 17	66	14
			Medium	>17 ≤ 36	54	11
			Large	>36	16	3
Total					136	28
Semi urban	3	3660	Small	≤ 8	366	19
			Medium	>8 ≤ 17	256	13
			Large	>17	31	2
Total					653	34
Rural	8	4546	Small	≤ 4	848	26
			Medium	>4 ≤ 9	355	12
			Large	>9	70	2
Total					1273	40

Primary data were collected from the sampled dairy farms through survey method. Data on the inventory, human labour use, composition of dairy herd, number of animals, their present value, capital investment, cost structure, input use, veterinary services, milk production, input-output prices etc. were collected from the selected dairy farms. The data pertained to the year 1999-2000.

The herd-size was homogenized by expressing the number of animals in terms of standard animal units (SAU) as explained below:

i) Cow and buffalo above 3 years — 1 SAU

ii) Young stock between 2 and 3 years — ½ SAU

iii) Young stock below 2 years — ¼ SAU

Break-even analysis

The break-even point is that level of output, at which total returns break-even with the total costs. It is the no profit and no loss point. Business starts earning profit when output increases above the break-even point. The break-even points in terms of milk production and productivity of milch animals were determined from the general equation given below:

$$P = QxS - F - QxV \quad (1)$$

Where,

F = fixed costs (Rs per dairy farm/ per SAU)

Q = quantity of milk produced (litres per dairy farm/per SAU)

V = net variable cost per litre of milk (Rs)

S = selling price of milk (Rs/litre)

P = profit (Rs per dairy farm/per SAU)

The break-even volume is the value of Q in equation (1) for which P = 0,

$$Q = F / (S-V)$$

The difference between unit selling price and the unit variable cost, is called the contribution margin or safety margin.

Appraisal of feeding inputs

The input elasticities in Cobb-Douglas production function were used to appraise the existing feeding levels. The validity of this methodology is illustrated as under:

$$Y = aX_1^{b1} X_2^{b2} X_3^{b3} e^u$$

Where Y = Milk production per animal per day (in litres)

b_0 = Constant

X_1 = Green fodder fed per animal per day (in kgs)

X_2 = Dry fodder fed per animal per day (in kgs)

X_3 = Concentrates fed per animal per day (in kgs)

b_1, b_2 and b_3 = Regression coefficients of the X_1, X_2 and X_3, respectively

e = Base of natural logarithm

u = Composite error term

For determining the profit maximizing level of inputs, the first derivatives of this production function with respect to feeding inputs were obtained and equated with input, output price ratios and the resulting equations have been expressed in terms of bi's (elasticity coefficients).

$$(dy/dx_i) = Px_i / P_y$$

or $$b_i Y/X_i = Px_i / P_y$$

or $$b_i = Px_i X_i / P_y Y$$

The equality of both sides (LHS and RHS) represented the optimum use of input.

If LHS > RHS, it indicates under use of input and

If LHS < RHS, it indicates over use of input.

Supply function

As in the short run, the variations in milk production are explained in large measure by the changes in the use of feeding inputs like green fodder, dry fodder and concentrates and, thus, only these inputs were considered for fitting the milk production functions in the short run for different dairy farming situations. The short run milk supply function was derived from the milk production function, specified in the previous section.

From the production function, the milk supply function has been derived and its general form is as follow:

$$M = a^{1/(1-b1-b2-b3)} (b_1/p_1)^{b1/(1-b1-b2-b3)} (b_2/p_2)^{b2/(1-b1-b2-b3)} (b_3/p_3)^{b3/(1-b1-b2-b3)} (p_m)^{(b1+b2+b3)/(1-b1-b2-b3)}$$

Where p_1, p_2 and p_3 are the unit prices of green fodder, dry fodder and concentrates and p_m is the price of milk per litre. The productivity levels of milch animals at optimum levels of feeding inputs have been computed and compared with their corresponding existing levels to study the potentials of dairy farming through optimization of feeding inputs at the existing herds of animals. Moreover, milk supply levels at alternative milk prices have also been determined.

Results and Discussions

Characteristics of Dairy Farms

The precise knowledge of the important characteristics of the dairy farms in the study area seems prerequisite for enhancing the practical utility of this empirical study. The information of these characteristics, is therefore, given in Table 3.

The perusal of this Table portrayed that the herd size witnessed an inverse relationship with the distance from the city. The average herd size in an urban farm situation was about two and half times larger than that of semi-urban and five times larger than that of rural dairy farms. The proportion of buffaloes in the average herd size was almost the same in all the farm situations.

Table 3: Herd Size and composition of livestock under different dairy farm situations.

(No.)

Dairy farm situations	Buffaloes	Total number of adult animals	Heifers	Calves	Total herd size (SAU)	Milk production (Litres)
Urban	21.00 (65.05)	28.55 (88.44)	1.41 (4.37)	2.32 (7.19)	32.28 (100.00)	72114.46
Semi-urban	7.94 (65.46)	10.50 (86.56)	0.65 (5.37)	0.98 (8.08)	12.13 (100.00)	24599.03
Rural	4 (62.70)	4.95 (77.59)	0.60 (9.40)	0.83 (13.01)	6.38 (100.00)	11492.60

Figures in parentheses indicate percentages to the total herd size.

The number of young stock per farm was found to vary inversely with the distance from the city. However, the proportion of young stock in the herd appeared to be much higher on rural farms than that of its counterparts in semi-urban and urban areas. There was a direct relationship between the proportion of adult animals and herd size. Milk production per farm in urban areas seems to be about three times higher than that of semi-urban and about six times higher than that of rural dairy farm situations. There was direct association between milk production and average herd size. So far as productivity was concerned, it witnessed an inverse relationship with the distance from the city. These observations lent support to the credence that in urban areas dairy entrepreneurs exploited the higher productivity potential of milch animals.

Fixed costs, variable costs and unit selling price being the determinants of break-even analysis, the variability of these parameters across farm situations was examined to study the causes of variability in break-even points. Annual fixed costs of dairy farm business include interest on investment, depreciation of animals, buildings, machinery and equipment. The annual fixed costs were computed per farm, per SAU and per litre of milk. Table 4 revealed that there were considerable variations in annual fixed costs across situations, not only on per farm basis but on per SAU and per litre of milk, too. It might be seen from this table that there was an inverse relationship between annual total fixed costs per farm which could be attributable to the inverse relationship of herd size with distance from the city as given in Table 1. These costs per S.A.U. and per litre of milk evinced direct association with distance from the city and inverse relationship with herd size which could be attributed to economies of size.

Table 4: Total annual fixed costs and net variable costs in different farm situations.

(Rs)

Dairy farm situations/ costs	Fixed cost per farm	Fixed cost per SAU	Fixed cost per litre of milk	Net variable cost per farm	Net variable cost per SAU	Net variable cost per litre of milk	Price of milk (Rs/ litre)
Urban	93244	2889	1.2930	482258	14939	6.69	11.99
Semi-urban	38067	3138	1.5475	138562	11422	5.64	10.46
Rural	20181	3164	1.7560	53751	9207	5.10	9.83

The variable costs of dairy farming include cost of fodder, feeds, fuel, electricity, water, labour, veterinary services, medicines, minor repair on buildings, machinery etc. The revenue from the sale of farm yard manure and imputed value of young animals have been deducted from the annual variable costs to compute the annual net variable costs which are given in Table 4. On an average, annual net variable costs per farm were the highest (Rs 482,258) on urban farms followed by semi-urban (Rs 138,562) and rural dairy farms (Rs 53,751). The corresponding figures for net variable costs per litre of milk were Rs 6.69, 5.64 and 5.10 for urban, semi-urban and rural areas, respectively, which witnessed an inverse relationship with the distance from the city. The decreasing net variable costs with the distance from the city could be attributable to the reduction in the dairy input prices with the increase of distance from the urban areas. These findings provide ample evidence of substantial differences in net variable costs across different dairy farm situations which necessitated the computation of break-even points across situations. On an average, the highest unit variable costs were recorded in case of urban farms and these were the lowest in case of rural dairy farms. The milk prices showed inverse relationship with distance from the urban areas.

Break-even Analysis

Break-even levels of milk production per farm and per SAU in different dairy farm situations had been computed and their sensitivity to variation in milk prices was determined and these figures are given in Table 5. The break-even levels per farm were 17,593, 7,998 and 4,267 litres of milk for urban, semi-urban and rural areas, respectively. The corresponding respective figures per SAU were 541, 651 and 699 litres. The lower break even points per SAU recorded on urban dairy farms among all the farm situations might be attributed to the larger economies of size and better management of dairy animals.

Table 5: Break-even levels of productivity and production of milk and its sensitivity variations in price of milk in different dairy farm situations.

(Quantity in litres)

Dairy farm situations	Urban	Semi-urban	Rural
Per Farm	17593.20	7897.72	4266.60
Per SAU	545.09	651.04	669.92
Variation in BEP with 10 per cent increase in prices of milk			
Per Farm	14345.23	6465.01	3534.32
Per SAU	444.46 (-18.46)	534.58 (-17.88)	554.11 (-17.16)
Variation in BEP with 10 per cent decrease in prices of milk			
Per Farm	22742.44	10097.34	5381.60
Per SAU	704.63 (29.26)	832.36 (27.85)	843.73 (26.13)

Figures in parentheses indicate the percentage change in the BEP over original BEP.

It can be seen from Table 5 that the break-even quantity decreased with the rise in prices of milk in all dairy farm situations. The impact of increase in milk price on break-even quantity per SAU was more pronounced in the urban dairy farm situation, and with 10 per cent upward revision in price of milk the break-even quantity per SAU decreased by 18.46 per cent. The decline in price of milk affected the BEP (Break-even point) adversely, with the fall in prices by 10 per cent, the BEP in terms of milk per SAU increased by 29, 28 and 26 per cent for urban, semi-urban and rural dairy farms, respectively, over the original B.E.P.

Appraisal of Input Use

For appraising the existing use of feeding inputs, the estimates of elasticity coefficients in Cobb–Douglas production function are compared with their corresponding expenditure return ratios and these results are presented in Table 6.

Table 6: Use of elasticites for resource mix appraisal.

Resource/ Situation	Green fodder		Dry fodder		Concentrates	
	Partial elasticites	Expenditure to returns ratio	Partial elasticites	Expenditure to returns ratio	Partial elasticites	Expenditure to returns ratio
Urban	0.2428	0.1329	0.1147	0.0860	0.2031	0.1633
Semi-Urban	0.2078	0.1569	0.1373	0.0597	0.2362	0.1582
Rural	0.1316	0.1719	0.1562	0.0628	0.3105	0.1063

It might be seen from this table that the coefficients

of partial elasticities were greater than their respective expenditure return ratios for feeding inputs in all the situations except the case of green fodder in rural situations. These comparisons of elasticities with their respective ratios of expenditure to returns revealed that there was over use of green fodder in the rural situation and there was under use of all feeding inputs in all other situations. It may be inferred from these results that curtailment in the use of green fodder in the rural situation and augmentation in the use intensity of green fodder, in other situations, and dry fodder and concentrates in all the situations would go a long way to improve the profitability of dairy farming in the selected area of study.

Milk Supply Functions

The milk supply functions were derived from the fitted production functions based on a cross-section of dairy farms in different situations. In these supply functions, milk supply has been expressed as the function of the prices of the milk and feeding inputs. Using the geometric means of input prices, milk supply is expressed as a function of milk price only. The main purpose of estimating a supply function is to determine the response of milk supply to the changes in its price, which is depicted by the magnitude of price elasticities in the supply functions.

The results of the fitted Cobb-Douglas production functions for different dairy farm situations were used to derive the supply functions. The results of fitted production functions for urban, semi-urban and rural dairy farm situations were:

$Y = 1.9768\ X_1^{0.2428}\ X_2^{0.1147}\ X_3^{0.2031}$ Urban

$Y = 1.8033\ X_1^{0.2078}\ X_2^{0.1373}\ X_3^{0.2362}$ Semi-urban

$Y = 1.5158\ X_1^{0.1316}\ X_2^{0.1562}\ X_3^{0.3105}$ Rural

Where X_1, X_2 and X_3 are as defined previously. All the regression coefficients were statistically significant in the above functions. By substituting the values of a, b_1, b_2, b_3, p_1, p_2 and p_3 in the supply functions we get;

Urban dairy farms

$$Y = (1.9768)^{1/0.4394}\ (0.2428 / 0.4834)^{(0.2428/0.4394)}\ (0.1147 / 1.3389)^{(0.1147/0.4394)}\ (0.2031/5.7032)^{(0.2031/0.4394)}\ P_y^{(0.5606/0.4394)}$$

Semi-urban dairy farms

$$Y = (1.8033)^{(1/0.4187)}\ (0.2078 / 0.3857)^{(0.2078/0.4167)}\ (0.1373 / 1.1419)^{(0.137/0.4187)}\ (0.2362 / 4.5280)^{(0.2362/0.4187)}\ P_y^{(0.5813/0.4187)}$$

Rural dairy farms

$$Y = (1.5158)^{(1/0.4017)}\ (0.1316 / 0.2295)^{(0.1316/0.4017)}\ (0.1562 / 0.9319)^{(0.1562/0.4017)}\ (0.3105 / 4.4521)^{(0.3105/0.4017)}\ P_y^{(0.5983/0.4017)}$$

The simplification of these functions gives the supply functions:

$Y = 0.362989\ P_y^{1.2758}$ for urban

$Y = 0.283862\ P_y^{1.3833}$ for semi-urban

$Y = 0.149600\ P_y^{1.4894}$ for rural dairy farms

The milk price elasticity in supply functions was found to be the highest (1.4894) in rural areas followed by semi-urban 1.3833 and urban 1.2758. This indicated that the supply of milk in urban, semi-urban and rural dairy farm situations was highly price responsive.

Milk supply responses to input-output prices

The relative effects on milk supply per animal of the variations in the prices of dry fodder, green fodder, concentrates and milk were studied and results set out in Table 5. The rest of the factors influencing the milk supply were assumed to be constant. The assumptions made to estimate the milk supply were:

I: Only the price of green fodder increased by 10, 25 and 50 per cent.

II: Only the price of dry fodder increased by 10, 25 and 50 per cent.

III: Only the price of concentrate feeds increased by 10, 25 and 50 per cent.

IV: The price of milk increased by 10, 25 and 50 per cent.

V: The price of milk as well as green fodder, dry fodder and concentrates, were increased simultaneously by 10, 25 and 50 per cent.

It can be seen from Table 7 that the milk supply decreased with the rise in prices of green fodder, dry fodder and concentrate in all the dairy farming situations. The impact of increased price rise of green fodder on milk supply was more pronounced in urban dairy farms, and with the upward revision in the price of green fodder by 10, 25 and 50 per cent the milk yield per animal per day decreased by 5.13,11.6 and 20.07 per cent, respectively. The effect on milk supply of the variation in the price of green fodder was the highest on urban dairy farms followed by semi-urban and rural dairy farms. This may be due to the reason that in urban

Table 7: Effect of milk yield per animal per day with variation in the prices of green fodder, dry fodder, concentrates and milk by 10, 25 and 50 per cent.

Situation	Green fodder			Dry fodder			Concentrate			Milk			Overall			Optimum milk yield at normal prices	Existing milk yield
	10%	25%	50%	10%	25%	50%	10%	25%	50%	10%	25%	50%	10%	25%	50%		
Urban	7.847	7.311	6.601	8.07	7.808	7.440	7.917	7.462	6.859	9.340	10.99	13.870	8.277	8.279	8.278	8.2709	7.1311
	(-5.13)	(-41.6)	(-20.07)	(-2.39)	(-0.56)	(-9.98)	(-4.28)	(-9.77)	(-17.07)	(12.93)	(32.94)	(67.74)	(0.073)	(0.104)	(0.092)		(13.78)
Semi-urban	6.701	6.589	5.745	6.809	6.529	6.15	6.658	6.194	5.589	7.923	9.456	12.168	6.941	6.936	6.930	7.0252	6.5441
	(-4.61)	(-10.48)	(-18.22)	(-3.08)	(-7.06)	(-12.46)	(-5.23)	(-11.83)	(-20.44)	(12.78)	(34.60)	(73.21)	(-1.200)	(-1.27)	(-1.360)		(6.848)
Rural	4.243	4.069	3.833	4.219	4.014	3.739	4.067	3.684	3.200	5.027	6.081	7.979	4.362	4.362	3.362	4.3614	4.3173
	(-2.72)	(-6.70)	(-12.12)	(-3.27)	(-7.97)	(-14.27)	(-6.75)	(-15.53)	(-26.63)	(15.26)	(39.43)	(82.93)	(0.013)	(0.013)	(0.013)		(1.011)

Figures in the parentheses indicate the percentage change in the milk supply over optimum milk supply.

areas due to higher price, use of green fodder was more conservative, thus, any reduction in the quantity of green fodder fed per animal in urban dairy farms due to further rise in its price has caused an adverse effect on the milk supply. This reduction in green fodder quantity further widened the gap between the original optimum fodder requirements and that of its revised optima.

In case of rural areas, the milk supply per animal per day got reduced only by 2.72, 6.7 and 12.12 per cent when the price of green fodder increased by 10, 25 and 50 per cent, respectively, this may be due to the reason that in rural areas due to the easy availability of green fodder, it was already adequately fed and when there was an increase in its price the reduction in green fodder consumption could not have a large adverse effect on milk yield.

The assumed increase in the price of dry fodder by 50 per cent in urban, semi urban and rural dairy farms caused a reduction in the milk supply to the tune of 9.98 per cent, 12.46 per cent and 14.27 per cent in the respective dairy farms. This could be attributed to the fact that in semi-urban and rural areas relatively larger replacement of dry fodder with green fodder had already brought down the proportion of dry fodder. Thus, any further reduction in its proportion due to increase in its price caused a relatively more constraining influence on the supply of milk in these areas as compared to urban areas.

Owing to the lower price of milk in semi-urban and rural areas, the use of concentrates remained on the lower side in these situations. Thus, any reduction in the use of concentrates has greater negative effect on per day per animal milk yield in semi-urban and rural dairy farms while green fodder was found to have a large adverse effect on milk yield in urban areas with the assumed increment in its price. The milk yield in rural areas was reduced by 6.75 per cent, 15.53 per cent and 26.63 per cent with assumed increase in price of concentrates by 10, 25 and 50 per cent, respectively, while in case of urban areas the milk yield got reduced by 4.28 per cent, 9.77 per cent and 17.07 per cent with the same percentage increase in its price. This could be due to the reason that use of concentrates in rural areas was lower as compared to urban areas. Thus, with any further reduction in the use of concentrates there was a higher proportion of losses in milk supply in rural areas.

The results of the milk supply functions have been found to be consistent with the logic of economic theory as increase in input prices lowered the milk supply and increase in milk price enhanced the supply of milk. A ten per cent increase in the price of milk has increased milk supply by 12.93 per cent in urban, 12.78 per cent in semi-urban and 15.26 per cent in rural areas. A further increase in the price of milk by 50 per cent has increased milk yield by 67.74 per cent in urban, 73.23 per cent in semi-urban and 87.93 per cent in rural areas. The least favourable impact of improved milk prices on milk supply in urban areas could be due to higher intensity in the use of dairy inputs being already achieved in this area. Thus, it indicates that the price of milk is one of the important factors on which the milk supply depends. The existing milk supply levels per animal being 7.13, 6.54 and 4.31 litres which were below the optimal milk supply levels by 13.78, 6.85 and 1.01 per cent in urban, semi-urban and rural dairy farm situations under the existing level of technology. These results indicated that there was a greater scope to increase the milk supply through judicious use of feeding inputs in urban and semi-urban areas. The narrow scope for improving milk supply through reorganization of existing feeding patterns in rural areas could be due to poor quality of milch animals, higher proportions of dry animals and young stock. These characteristics of dairying in rural areas made the marginal cost curves more

steep, thus, leaving a little scope for improving milk supply through optimization of feeding patterns at the prevailing price of inputs and output. However, with improvements in milk prices, the milk supply is bound to increase substantially in all the dairy farming situations.

Conclusions

The effect of milk price on break-even quantities of milk per dairy household and per SAU was more pronounced in urban areas. The optimality criteria suggested curtailment of green fodder in rural situations and augmentation in the feeding intensity of inputs in other situations for maximization of profits from dairying under the existing level of technology. The responsiveness of milk supply to its price was found to be the highest in rural situations followed by semi-urban and urban situations. The price of green fodder was a more predominant determinant of milk supply in urban areas while the price effect of the concentrate was more pronounced on the milk supply in other dairy farming situations.

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Stressing output is the key to improving productivity, while looking to increase activity can result in just the opposite.

– Andrew Grove

Feature

Indian Agriculture: A Post-Green Revolution Era

Rudra Prakash Pradhan

Agriculture is the lifeline of the Indian economy and continues to be central to all strategies of planned socio-economic development in the country. To achieve this, the Government has always launched a number of plans and programmes. But, the first major success came out in the form of the green revolution in the mid sixties. Green revolution has already proved that the achievement of productivity is technically feasible. Therefore, the present paper attempts to examine the post-green revolution impact on agricultural development in India. The paper finds fertilizer is the kingpin that ensures agricultural productivity in India.

Rudra Prakash Pradhan is a Faculty Member, GIDC Rofel Institute of Management Studies (GRIMS), Vapi.

Agriculture is a major sector in India and continues to be the lifeline for the Indian economy. At a minimum, its contribution to the Gross Domestic Product (GDP) is about 27% (Ranganathan, 2003), sustains livelihood to about 64% (Navalgund, 2002; Sharma, 2002), employs about 69% of the total workforce, contributes about 12% to the export growth and is a major source of poverty alleviation and empowerment of the agrarian folk (Singh, 2002). Rapid growth of agriculture is, therefore, essential to achieve the multi-pronged objectives of the Indian planning system. These include self-reliance at the national level, food security to individual households, equitable distribution of income and wealth, rapid reduction of poverty levels, absorbing the growing labour force, facilitating export growth, which restores the balance of payments equilibrium in the economy, and so on (Government of India, 2001).

In the present scenario, providing food security to the ever increasing population of our country, Indian agriculture faces an uphill task. It is estimated that by 2020 A. D., food requirement will be about 235 million tonnes against the 203 million tonnes of existing food grains production. It is, therefore, time to take stock of the developments in Indian agriculture and see where we stand and how to proceed further (Srinivasan, 2003). This is, in fact, possible under three different heads, viz., increasing area under cultivation, increasing cropping intensity and increasing agricultural productivity (Navalgund, 2002). However, in a country like India, the third possibility is much more important than the other two due to increasing pressure of urbanization and industrialization. The term 'productivity' implies the value of output per unit of Net Sown Area (NSA), which depends upon a number of factors and can be grouped under four heads, viz., infrastructural, technological, institutional and environmental. The basic aim of this paper is, therefore, to describe the productivity issue of agriculture, which is considered as one of the desired solutions to meet the food requirements of our nation and other plan objectives (Mohammad, 1979).

Keeping the above view in mind, the Government of India has always launched a number of schemes and programmes from time to time during the last four decades in different parts of the country (Iqbal, 1979). Thanks to Dr. Swaminathan and Shri C. Subramaniam, who first contributed to the major success in Indian agriculture in the form of new agricultural technology, which was popularly known as 'green revolution' in the mid sixties. The term 'green revolution' is a general one, which was applied to successful agricultural experiments in many third world countries. But, it was most successful in India. Supporting this, Sharma (2002) pointed out that green revolution has been the cornerstone of India's agricultural achievement, transforming the country from one of food deficiency to self-sufficiency.

The strategy of this technology is in the form of a package of programmes woven around High Yielding varieties (HYVs) and include other inputs such as adequate irrigation, chemical fertilizer, plant protection chemicals, mechanization of agriculture, supply of electricity, credit and marketing facilities on a co-operative basis and a system of superior prices and buffer stocking. The whole idea is to demonstrate how productivity can be raised without increasing the area under cultivation (Singh et al., 2000). The programme gained momentum primarily due to its initial success during 1967-68, and as a result, the positive effect has spread in many directions viz. statistically, economically, sociologically and politically.

In a nutshell, green revolution resulted in a record gain of output from 51 million tonnes in 1950-51 to 131 million tonnes in 1978-79. This established that India was one of the biggest agricultural producers in the world. No other countries in the world, which attempted the green revolution, recorded such a level of success. India also became an exporter of food grains around that time. Yield per unit of NSA improved by more than 30% between 1947 and 1979, when the green revolution was considered to have delivered its goods. The crop area under HYV varieties grew from 7% to 22% of the total cultivated area during the 10 years of the green revolution. During this period, the area of HYV was covered by wheat (around 70%), rice, millet and some other crops. Crop area under HYV needed more water, fertilizer, pesticides, fungicides and certain other chemicals. This spurred the growth of the local manufacturing sector and helped the Indian economy in terms of employment generation, and its contribution to the country's GDP.

Yield per unit of NSA improved by more than 30% between 1947 and 1979.

On the other side, the increase of irrigation demanded the creation of new dams in order to harness the monsoon water which was used for creating hydroelectric power. This, in turn, again boosted industrial growth, created jobs and improved the quality of life of the people in villages. During this period, India also paid back all loans, which had been taken from the World Bank and its affiliates for the purpose of the green revolution. This improved India's creditworthiness in the eyes of the lending agencies. Some developed countries, especially Canada, which were facing a shortage in agricultural labour, asked the Indian government to supply them with farmers experienced in the methods of the green revolution. Many farmers from Punjab and Haryana states in northern India were, thus, sent to Canada, where they settled. These people remitted a part of their incomes to their relatives in India. This not only helped their relatives in India but also added, even if modestly, to India's foreign exchange earnings.

At the same time, India also transformed itself from a starving nation to an exporter of food. This earned admiration for India in the comity of nations, especially in the Third World. Further, green revolution was one of the factors that made Mrs Indira Gandhi (1971-1984) and her party, the Indian National Congress, a very powerful political force in India (http://www.indiaonestop.com). While recognizing the impact of green revolution in imparting dynamism to the agricultural sector, it must be recognized that the revolution remained restricted to the well-endowed, irrigated areas of the country. Of late, decelaration in production in some of the major irrigated production systems, especially in the north and north-west regions, has been recorded. Potentially, high production areas (eastern and central states) are still lagging behind in the productivity issue. Moreover, in the area of agricultural research, success has been restricted to some selected crops. Even in this arena, a growing disparity has been found between the actual and the potential yields, which points to a crucial gap between research and extension.

It is, in fact, true that public research and extension played a major role in bringing the green revolution in India across its regions. However in the post-green revolution era, extension faces important challenges in the areas of relevancy, accountability and sustainability. The changing economic scenario in India and the need for appropriate agricultural technologies and agro-management practices for responding to food and nutritional security, poverty alleviation, diversifying market

demands, export promotion and environmental degradation, are posing new challenges to the technology dissemination systems. Further, it is expected that future agricultural growth would largely depend upon the improvements in productivity diversified farming systems along with regional disparity and sustainable management of natural resources, especially land and water (Sharma, 2002).

In the light of the above backdrop, the present paper makes an attempt to examine the green revolution impact on agricultural development in India during the pre- and post- reforms scenario. It, first, examines the trends of agricultural inputs, which were very popular during the green revolution period. Then, it examines the inter-regional variation in the adoption of such inputs and the productivity of agriculture. It also studies the impact of such inputs on agricultural productivity. Finally, the paper concludes with certain well thought out recommendations.

Databases and Methodology

The study, under the present scenario, is primarily based on secondary data and has been collected from various sources from 1984-85 to 1999-2000. The most important sources are:

- Centre for Monitoring Indian Economy
- Hand book of Statistics on Indian Economy
- Indian Economic Survey

To begin with, the study first identifies the components that played a catalystic role in green revolution technology. Based on the findings of Bhagat (1983), Dadibhavi (1986), Singh (2000), Ut et al. (2000), Rao (2001) and knowledge of the Indian farming system, consumption of chemical fertilizer, adoption of High Yielding Varieties (HYVs), the availability of necessary agri-infrastructure - irrigation, transport, power, finance, marketing, etc., and other agricultural inputs such as machines, rainfall etc. are selected to be instrumental for agricultural productivity in the production function framework. However, due to data consistency and relevance of the present study, we have taken fertilizer, HYV, irrigation and rainfall as the major components for determining agricultural productivity. Further, to study the effect of Indian agriculture during the post-green revolution period, we have taken the relevant time series data of both major inputs and output for a period of 22 years and then grouped the whole data into two different time periods, viz., 1980-81 to 1990-91 (pre-reforms period) and 1991-92 to 2001-02 (post-reforms period).

A variety of models are available in the literature of applied econometrics to capture the dynamic input-output relations. The present study, however, has applied the wide use of Cobb-Douglas (C-D) production function, which is relevant for different sectors of agriculture and manufacturing industries. The general form of C-D type production is as follows:

$$Y = AX_1^{\alpha 1} X_2^{\alpha 2} X_3^{\alpha 3} X_4^{\alpha 4}$$

Now, taking logarithm on both sides, we have

$$\text{Log } Y = \log A + \alpha_1 \log X_1 + \alpha 2 \log X_2 + \alpha_3 \log X_3 + \alpha_4 \log X_4$$

Where, Y = Yield of food grains production (kg/ha)

X_1 = Total consumption of chemical fertilizer (kg/ha)

X_2 = HYV area as a percentage of area under food crops (%)

X_3 = Net Irrigated Area as a percentage of Net Sown Area (%)

X_4 = Actual rainfall as a percentage of normal rainfall (%)

A, α_1, α_2, α_3, and α_4 are the parameters to be estimated.

Production Behaviour of Indian Agriculture: Trends and Impact

Trends of Foodgrain Production in Indian Agriculture

Food grain production occupies the most dominant position in India's agriculture, which covers over 65% of the Gross Cropped Area (GCA). Since the beginning of the green revolution in the mid 1960s, the country has shown quite impressive growth in food grain production. Chronic food deficits and a hovering Malthusian crisis were overcome and that has given way to self-sufficiency in food grains and occasional marginal surpluses by the 1980s and 1990s. However, with the population growing at nearly 2 percent per year (nearly 18 to 20 million people being added every year) and accelerating income growth, demand for food is continuously growing in the economy. India's food grain production has also been increasing rapidly over the years.

In estimation, India's food grain production has increased from a low of 50,825 thousand tonnes in the early fifties (1950-51) to 82,018 thousand tonnes in the early sixties (1960-61) and then to 95,052 thousand tonnes in the early phase of the green revolution (1967-68).

The food grains production further increased to 152,374 thousand tonnes in 1983-84 and to 171,036 thousand tonnes in 1989-90. However, during the early phase of economic reforms (1990-91), the food grain production was 176,309 thousand tonnes and decreased to 167,065 thousand tonnes in 1991-92. This was probably due to the erratic nature of monsoon in the country (see rainfall index in Table 2). But, despite the same erratic nature of rainfall, the amount of food grains production was increased to 208,875 thousand tonnes in 1999-2000. This suggests that economic reforms had a positive impact on green revolution for increasing the food grains production in the economy. Yield of food grains per hectare of NSA also increased substantially from a low of 522 kg/ha in 1950-51 to a high of 759 kg/ha in 1967-68 and then to 1700 kg/ha in 1999-2000. There has also been a phenomenal rise in the size of the cultivable area. In 1950-51, the total amount of cultivable land was 97,321 thousand hectares which increased to 121,421 thousand hectares in 1967-68 and then to 123,059 thousand hectares in 1999-2000 (Table 1).

Table 1: Food grain production in India

Year	Area	Production	Yield
1950-51	97,321	50,825	522
1960-61	115,581	82,018	710
1967-68	121,421	95,052	759
1983-84	131,163	152,374	1162
1989-90	126,773	171,036	1349
1990-91	127,835	176,390	1380
1991-92	121,605	167,065	1374
1999-2000	123,059	208,875	1700

Note: Area in thousand hectares; Production in thousand tons; and Yield in kg/ha.

Trends of Inputs used in Indian Agriculture

Based on the literature of the different studies and the knowledge of the Indian agricultural system, fertilizer, HYV, irrigation and rainfall are treated as the major components for determining the production/productivity in agriculture. The trends of the above inputs have increased over the years except rainfall, which exercises large-scale regional-variation with respect to time span (Table 2).

It is to be noted here that during the early phase of planning (1950-51), the amount of irrigation (measured as Net Irrigated Area (NIA) as a percentage of NSA) and fertilizer (measured as per hectare consumption of chemical fertilizer (NPK)) were just 17.56% and 0.48 kg. However, both increased to 19.44% and 9.4 kg in 1967-68 and 32.81% and 63.5 kg in 1989-90. During the early phase of economic reforms, the figures were 33.58% and 67.5 kg and then increased to 39.21% and 88.85 kg in 1999-2000 (Table 2).

Table 2: Trends in major inputs used in food grain production

Items	Irrigation	Fertilizer	HYV	Rainfall
1950-51	17.56	0.48	NA	–
1960-61	18.51	1.91	NA	–
1967-68	19.44	9.40	NA	–
1983-84	29.37	42.9	41.0	113
1989-90	32.81	63.5	48.3	101
1990-91	.58	67.5	50.9	106
1991-92	35.21	69.8	53.1	91
1999-2000	39.21*	88.85*	63.5*	96

Note: Irrigation: NIA as a % of NSA; Fertilizer: Per hectare consumption of chemical fertilizer; HYV: HYV area as % of Area under food crops; and Rainfall: Actual rainfall as percentage of normal rainfall; *: Provisional figures.

Corresponding to the figures of irrigation and fertilizer, the coverage of HYV (measured as a percentage of area under food crops) and rainfall (measured as actual rainfall as a percentage of normal rainfall) were 41% and 113% during the early phase of the green revolution. These increased to 48.3% and 101% in 1989-90. However, during the early phase of economic reforms, these figures were 50.9% and 106% which increased to 63.5% (HYV) and decreased to 96% (rainfall) in 1999-2000 (Fig. 1).

During the early 1980s, the relative figures of irrigation, fertilizer, HYV area and agricultural productivity were 27.66%, 32.0 kg, 34.00% and 1360 kg/hectare which increased to 33.58%, 67.5 kg, 50.90% and 1740 kg/hectare in 1990-91 and further to 39.83%, 92.98 kg, 65.30% and 2255 kg/hectare in 2001-02. However, considering the trends of these inputs and outputs under the present scenario, the growth rates of all these items during the pre-reforms period was higher than that of the post-reforms period. This could be seen from Table 3. During the pre-reforms period (1980-81 to 1990-91), the growth rates of productivity, irrigation coverage, fertilizer consumption, HYV adoption and average rainfall were 2.01%, 0.813%, 3.17%, 1.61% and 0.15%. However, the figures have been changed substantially to 0.586%, 0.557%, 1.63%, 0.977% and - 0.44% during the post-reforms period (1991-2002). These results reflected that the trends of agricultural inputs and agricultural productivity were not favorable during the post-reforms period. This might be due to the impact of the reforms process. But by the trend of rainfall, it was, in fact, clear that the erratic nature of rainfall during the post-reforms

period substantially affected the inputs consumption and agricultural productivity. This could also be verified with the help of regression analysis in the next section.

Table 3: Growth Rates of Agricultural Inputs and Agricultural Productivity

Items	Pre-Reforms Period	Post-Reforms Period
Productivity	2.010	0.586
Irrigation	0.813	0.557
Fertilizer	3.170	1.630
HYV	1.610	0.977
Rainfall	0.150	-0.044

Note: Pre-reforms Period: 1980-81 to 1990-1991; Post-reforms Period: 1991-2002

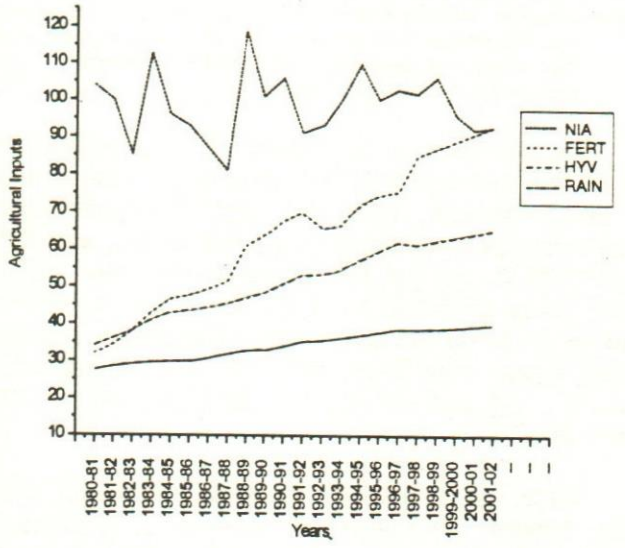

Fig. 1. Trends of Agricultural Inputs during pre and post reforms period

The Impact of Agricultural Inputs on Productivity

The present section examines the inter-relationship among the inputs and the impact of all these inputs on agricultural productivity during both the periods. The first section has been examined with the help of variance and covariance matrix and the next section has been examined through the application of regression analysis.

By the correlation matrix, these four variables - irrigation, fertilizer, HYV and rainfall, we have studied the inter-relationship among these variables. Table 4 and 5 represents the said correlation matrix. The results of the above table reflected that the correlation between irrigation and fertilizer is 0.976 and this may be because of increase in irrigation coverage and the consumption of fertilizer in Indian agriculture. Similarly, the correlation between fertilizer and HYV is also high at 0.982. This suggests that the consumption of chemical fertilizer is substantially consistent with HYV adoption. Further, correlation between irrigation coverage and HYV adoption is also of 0.961. This reveals that irrigation attracts HYV adoption in Indian agriculture. From these results, it appears that the regression estimation is likely to be influenced by multicolinearity and the regression procedure may find it difficult to separate the effects of these three inputs on agricultural productivity. Therefore, their coefficient magnitudes could be unstable and may reflect the effects of each other. It may also be noted that rainfall does not have a high correlation with any of these inputs, which probably is due to high coverage of irrigation in the food grains production.

The consumption of chemical fertilizer is substantially consistent with HYV adoption.

Table 4: Variance-Covariance Matrix of Explanatory Variables (Pre-reforms)

	NIA	FERT	HYV	RAIN
NIA	1.00			
FERT	0.976	1.00		
HYV	0.961	0.982	1.00	
RAIN	0.154	0.242	0.134	1.00

Note: NIA: Net irrigated Area; FERT: Fertilizer; HYV: High Yielding Varieties; and RAIN: Rainfall.

Table 5: Variance-Covariance Matrix of Explanatory Variables (Post-reforms)

NIA	FERT	HYV	RAIN
NIA	1.00		
FERT	0.922	1.00	
HYV	0.995	0.933	1.00	
RAIN	0.098	-0.12	0.066	1.00

Note: Notations are already defined early.

The regression output under Cobb-Douglas production function for the two different periods under the present study are given in Table 6. Here, we have applied step-wise regression for avoiding multicolinearity problems and restoring the consistency of variables. Here, in both the reform periods (pre- and post-), fertilizer was found to be the main determinant of agricultural productivity in India. This is because all other items

are being excluded by the step-wise regression. Its impact on agricultural productivity is highly positive and significant at the level of 1%. However, the impact is stronger in the case of the post-reforms period in comparison to the. pre-reforms period. This has been derived by the values of Coefficient Determination (R^2), which is 0.722 in the pre-reforms period and increased to 0.838 in the post-reforms period. Further, the value of R^2 represent that about 72% (pre-reforms period) and 84% (post-reforms period) of the systematic variation in agricultural productivity is explained by the factor of fertilizer after excluding other agricultural inputs. The value of F-statistics is also significant at the significance level of 1% in each case, indicating significant linear relationships that exist between the dependent variable (Agricultural Productivity) and independent variables. The Durbin-Watson statistics in both the cases suggest that the presence of serial correlation is no more a problem for the above analysis.

With regard to the impact of other variables on agricultural productivity, the impact of irrigation and HYV are negative and rainfall is positive for the pre-reforms period. However, in the post-reforms period, only HYV traces negative impact on agricultural productivity. But in both the situations, all excluded variables are not significant at all. This is because of fertilizers' significant impact on agricultural productivity. These results suggest that fertilizer determines the very level of agricultural productivity in both the reforms period under the present study, while other factors are playing a supporting role towards the same.

Table 6: Regression Results

Period	DV	IV	β Coefficients	Standardized B	t-Statistics
Pre Reforms	AGP	Constant	2.008 (0.244)		9.305
		FERT	0.647 (0.134)	0.850	4.835
		R^2	0.722		
		F	23.38		
		DW	1.780		
		ES			
		NIA		-0.968	-1.375
		HYV		-0.901	-0.695
		RAIN		0.233	1.365
Post Reforms	AGP	Constant	2.64 (0.100)		26.295
		FERT	0.361 (0.053)	0.915	6.818*
		R^2	0.838		
		F	46.483		
		DW	2.881		
		ES			
		NIA		0.066	0.177
		HYV		-0.120	-0.301
		RAIN		0.084	0.597

Note: Figures in parentheses are standard errors; *: Significant at 1 per cent level of probability; AGP: Agricultural Productivity; RINF: Composite Index Rural Infrastructure; R^2: Coefficient Determination; DW: Durbin Watson Statistics; DV: Dependent Variable; IV: Independent Variables; ES: Excluded Statistics; F: F-Statistics.

Conclusion and Suggestions

The above analysis clearly envisages that the adoption of chemical fertilizer is the main factor, which determines the productivity of agriculture in the Indian economy. However, it has to be supported by other important agricultural inputs like irrigation, HYV, rainfall, etc. In the face of positive impact of fertilizer on agricultural productivity, we are indeed faced with a more challenging task. This is because with a view to increase food grain production and other planning objectives, we might lean upon the use of more fertilizers and more pesticides, which would have adverse effects on ecology, environment and health conditions of both human beings and animal species on earth. Further, it is true that an increase in the critical input 'fertilizer' above the optimal level may amount to significant rise in production/productivity. However, under the given circumstances, an economy cannot afford to increase such inputs, as they would be detrimental to sustainable agriculture. Moreover, the present use of resources should not deplete the resource-base to such an extent that the development process becomes dependent and is not sustainable in the future (Nadkarni, 1987). Keeping the above facts in view, it is required for an economy to find suitable alternatives of these inputs, particularly of fertilizers, while simultaneously restoring environmental sustainability. These include:

- Since organic manures contain all these nutrients as possessed by chemical fertilizers, the farmers need to replace the latter's excessive use either wholly or partially (Nath, 1996).
- Integrated Nutrient Management (INM) and Integrated Pest Management (IPM) techniques need to be properly developed to achieve efficiency and sustainability of agriculture for different regions (Kumar and Narwade, 2001).
- A change in the land use pattern, shifting focus from higher output to better livelihood, would be helpful for sustainable agriculture in the long run.
- Population growth has to be curbed at all costs. Fertilizers and pesticides may enhance food production up to a certain extent after which

land degradation will set in due to overuse of the chemicals on soil and over-exploitation of land and, thus, production will decline. Further, with a tremendous growth in population, India in the coming years will not remain as self-sufficient in food grains as it is today. Therefore, if drastic measures are not adopted to check population growth, despite all endeavours to enhance agricultural production we shall be unable to avert hunger, malnutrition and disease in the economy.

- Over and above all the preceding measures, there is a need for proper development of the communication and extension system. This helps address the peripheral problems of a more urgent nature relating to our sustenance in a better way. Specifically, this helps stress on situations, objectives, problems and solutions of the earlier mentioned subject of productivity and sustainability in agriculture (Sharma, 2002; Hussain, 2002). Further, to strengthen the communication and extension system, there is a need to strengthen both formal and informal education (Hussain, 1979; Tillak, 1993) for the farming community.
- There is a great need of decentralizing planning in the district level through the creation of an Agricultural Technology Management Agency (ATMA) (Sharma, 2002).
- There is a great need for creating the necessary infrastructure in the economy, especially for the agricultural sector.

A piece-meal approach to such a vital sector of the economy, particularly with respect to productivity and sustainability, would have serious consequences. What is urgently required is to sustain environmental friendly sustainable agriculture in the economy. This demands integrating agriculture with all other important sectors of the economy.

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Feature

Productivity Trends in Agriculture: A Future Strategy

Sanjeev Gupta & R.S. Bawa

This paper examines the need to take strategic policy measures to improve the productivity of the Indian agricultural sector in order to transit from extensive, low productivity agriculture to intensive, high productivity agriculture. With a view to enable policy makers aware of prevailing trends in productivity, the present paper aims at the measurement of long-term trends and analysis of growth performance of the productivity of fourteen principal crops over a period of fifty two years. Long-term trends of productivity were captured by fitting ten distinct functional forms and the equation of best fit was selected on the basis of yardsticks mentioned in the econometric literature. The findings have been supplemented with necessary recommendations for enhancing productivity.

Sanjeev Gupta is Senior Faculty Member of Apeejay Institute of Management, Jalandhar and R.S. Bawa is presently Professor of Economics and Registrar, Guru Nanak Dev University, Amritsar.

Agriculture is a driver of growth. All the three basic objectives of economic development of the country, namely, output growth, price stability and poverty alleviation, are best served by the growth of the agricultural sector. When we look at the state of agriculture at the world level, we find two distinct types of farming. In developed countries agriculture is highly efficient with substantial productive capacity and high output per worker resulting in permitting a small number of population to feed the entire population. Whereas in the case of developing agrarian economies like India, productivity is very low and the agricultural sector can barely sustain the farm population.

India has made a lot of progress in agriculture since independence and this sector has resulted in substantial increase in terms of growth of output, productivity and area under many crops. But, if we compare growth performance of Indian agriculture with the performance of agriculture of the developed economies, we will realize there is an urgent need to improve the productivity of this sector. A transition from extensive, low productivity agriculture to intensive, high productivity agriculture is a fundamental pre-requisite for the development of our agrarian economy. Productivity growth helps to reduce per unit cost of production and acts as a real indicator of progress in crop production activities.

A number of researchers like Rudra (1970); Dey (1975); Reddy (1978) Rao (1980); Nadkarni (1980); Dandekar (1980); Bawa and Kainth (1980); Jayalakshmi (1988); Achutan and Sawant (1995); Naik (1997); Alam (1997); and Gill (2002) have estimated the growth trends of principal crops at the aggregate and disaggregate level, by using one or more of the conventional functional relationships. But the present study is a more elaborate one; as many as ten alternative trend relationships are considered to study long-term trends.

Objectives of the Study

Academicians, planners and policy makers have stressed the need to understand the prevailing trends in the productivity of the agricultural sector and analysis of growth performance to frame a sound agricultural development strategy. In this paper, an attempt has been made to examine long-term trends and the growth behaviour of productivity of fourteen principal crops in order to make policy makers aware and to have a more realistic understanding of the future prospects of Indian agriculture.

The specific objectives of the study were:

1. To examine prevailing trends in the productivity of principal crops.
2. To analyse the growth performance of principal crops.
3. To study the impact of liberalisation on productivity of Indian agriculture.
4. To recommend policy measures for enhancing productivity.

Data Base and Analytical Framework

The study is based on secondary data for a period of 52 years covering the period 1950-51 to 2001-2002. The data relating to the productivity for fourteen principal crops for the above said period were culled from various issues of 'Agricultural Statistics at a Glance' published by 'Directorate of Economics and Statistics', Ministry of Agriculture, Government of India, New Delhi. For the present analysis we have analyzed long-term trends and computed compound annual growth rates of productivity for the entire period (P) [1950-51 to 2001-2002] and three sub-periods, viz., pre – Green Revolution (PrGr) [1950 – 51 to 1966 – 67], Green Revolution (GR) [1966 – 67 to 1975 – 76] and post – Green Revolution (PoGr) [1975-76 to 2001-2002]. In order to analyse the impact of liberalization on growth performance, the period of post green revolution was further subdivided into pre – liberalization period (1975 – 76 to 1990 – 91) and liberalization period (1990 – 91 to 2001-2002).

For identifying the appropriate long-term trend pattern followed by time-series data on fourteen principal crops, the following ten distinct functional forms were estimated.

1.	Simple Linear (SLR)	$Y_t = \beta_0 + \beta_1 t + U_t$
2.	Parabolic (PRB)	$Y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + U_t$
3.	Cubic (CUB)	$Yt = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + U_t$
4.	Inverse (INV)	$Y_t = \beta_0 + (\beta_1/t) + U_t$
5.	Logarithmic (LOG)	$Y_t = \beta_0 + \beta_1 \ln t + U_t$
6.	Exponential (EXP)	$\ln Y_t = \ln\beta_0 + t \ln \beta_1 + U_t$
7.	Geometric (GEO)	$\ln Y_t = \ln\beta_0 + \beta_1 \ln t + U_t$
8.	Parabolic in Logarithms (PLG)	$\ln Y_t = \ln \beta_0 + t \ln \beta_1 + t^2 \ln \beta_2 + U_t$
9.	Cubic in Logarithms (CLG)	$\ln Y_t = \ln \beta_0 + t \ln \beta_1 + t^2 \ln \beta_2 + t^3 \ln \beta_3 + U_t$
10.	S-Curve (S)	$\ln Y_t = \beta_0 + (\beta_1/t) + U_t$ ...(1)

Where Y_t stands for the value of a given time series at time t; β_0, β_1, β_2, and β_3 stand for the unknown parameters; Ut stands for the disturbance term. All the functional forms were estimated by applying Ordinary Least-Squares (OLS) method.

From amongst the various tried functional forms, a particular equation was finally considered appropriate out of competing trend equations if it is associated with (i) high value of R^2, (ii) value of D-W statistics close to 2, and (iii) significant 't' and 'F'. All the mentioned yardsticks were not expected to be uniformly in agreement with each other. Final choice of equation of best fit was made for that functional form which satisfied the maximum number of criteria. In order to work out above yardsticks for each of the estimated functions, a set of residuals $\{e_t\}$ were computed in order to construct R^2 and D-W statistics. The significance of R^2 was tested by applying F-test and simple t-test was applied on the regression coefficients for testing their significance. In order to analyse growth performance compound annual growth rates were computed by fitting an exponential function and their significance was tested by applying the t-test.

Results and Discussion

The results have been discussed in brief under the following sub-heads:

Long-term trends

Fitting of ten functional forms to yield per hectare for fourteen crops resulted in one hundred forty (140) fitted equations and out of all these fitted equations, the

final choice of equations of Best Fit was made on the basis of the above mentioned yardsticks. This whole exercise resulted in 14 equations of best fit for all the fourteen crops. The equations of best fit along with the estimates of their parameters, R^2, D-W and F-statistics in the case of each crop have been represented in Table 1.

Perusal of Table 1 revealed that PRB was found to be best fit in case of five crops, namely, food grains, rice, total pulses, nine oilseeds and jute & mesta. In case of food grains and rice, trend coefficient was positive, whereas, it was negative in case of total pulses, nine oilseeds and jute & mesta. In cases of all the five crops, individual regression coefficients as well as overall fit of regression was significant. In case of all the crops except total pulses, R^2 was very high.

Further perusal of Table 1 conspicuously revealed that out of competing functional forms CUB function was found to be best fit in case of wheat, maize, grams

Table 1: Estimates of the Parameters of Trend Equation of Best Fit in case of Yield for all the Fourteen crops at the all India level from 1950-51 to 1999-2000.

Foodgrains (PRB)	**Rice (PRB)**	**Total Pulses (PRB)**	**Nine Oilseeds (PRB)**
b_0 = 585.656	b_0 = 780.983	b_0 = 481.299	b_0 = 494.161
b_1 = 1.288	b_1 = 7.102	b_1 = -1.816	b_1 = - 4.132
b_2 = 0.422	b_2 = 0.345	b_2 = 0.087	b_2 = 0.242
D-W = 1.814	D-W = 1.708	D-W = 2.073	D-W = 1.963
F = 1434.486	F = 524.918	F = 31.141	F = 180.945
R^2 = 0.983	R^2 = 0.955	R^2 = 0.560	R^2 = 0.881
Jute & Mesta (PRB)	**Wheat (CUB)**	**Maize (CUB)**	**Grams (CUB)**
b_0 = 1075.272	b_0 = 724.669	b_0 = 589.997	b_0 = 531.548
b_1 = -11.177	b_1 = -12.262	b_1 = 41.274	b_1 = 8.541
b_2 = 0.550	b_2 = 1.938	b_2 = - 1.404	b_3 = 0.005
D-W = 2.00	b_3 = - 0.018	b_3 = 0.0217	b_2 = - 0.302
F = 360.085	D-W = 1.704	D-W = 2.072	D-W = 2.450
R^2 = 0.936	F = 1191.229	F = 172.671	F = 21.696
	R^2 = 0.987	R^2 = 0.915	R^2 = 0.576
Tur (CUB)	**Bajra (CLG)**	**Rapeseed Mustard (CLG)**	**Cotton (CLG)**
b_0 = 819.302	b_0 = 264.542	b_0 = 401.818	b_0 = 93.878
b_1 = -21.269	b_1 = 1.028	b_1 = 0.989	b_1 = 0.997
b_2 = 0.923	b_2 = 0.999	b_2 = 1.013	b_2 = 1.001
b_3 = -0.011	b_3 = 1.000	b_3 = 0.999	b_3 = 0.999
D-W = 2.312	D-W = 2.245	D-W = 1.991	D-W = 1.642
F = 2.302	F = 42.758	F = 98.358	F = 142.251
R^2 = 0.126	R^2 = 0.728	R^2 = 0.860	R^2 = 0.899
Potato (CLG)			**Groundnut (SLR)**
b_0 = 46.946			b_0 = 646.611
b_1 = 0.993			b_1 = 6.960
b_2 = 1.000			D-W = 2.095
b_3 = 0.999			F = 50.173
D-W = 2.013			R^2 = 0.501
F = 305.900			
R^2 = 0.950			

Table 2: All India compound *Growth Rates of Yield per hectare* of fourteen principal crops

Crops	1950-67[I]	1966-76[II]	1975-2002[III]	1975-91[IV]	1990-2002[V]	1950-2002[VI]
1	2	3	4	5	6	7
Food grains	1.445 (4.264)	2.515 (3.314)	2.742 (24.552)	2.662 (7.957)	2.696 (10.127)	2.364 (39.825)
Rice	1.859 (3.838)	2.242 (2.864)	2.317 (14.324)	2.665 (5.641)	1.319 (5.347)	2.000 (28.216)
Wheat	1.503 (4.055)	3.531 (3.470)	2.812 (23.219)	3.445 (13.464)	1.724 (6.898)	3.163 (40.446)
Bajra	1.444 (2.735)	1.256 (0.440)*	2.273 (4.633)	0.576 (0.464)*	2.617 (1.751)	1.926 (11.247)
Jute & Mesta	0.224 (0.770)	1.276 (1.291)	2.254 (16.368)	2.364 (5.829)	1.444 (6.309)	1.338 (14.758)
Maize	3.158 (7.532)	0.4008 (0.298)*	2.419 (10.517)	1.968 (2.748)	2.491 (6.155)	1.842 (18.241)
Total Pulses	-0.34 (-0.714)	0.562 (0.424)*	0.864 (5.218)	0.98 (1.799)	0.592 (1.157)	0.531 (6.336)
Grams	-0.08 (-0.128)*	0.810 (0.468)*	1.016 (4.171)	0.20 (0.284)*	1.304 (2.304)	0.788 (7.066)
Tur	-1.99 (-2.874)	2.908 (1.561)	-0.266 (-1.003)*	0.468 (1.095)	-0.404 (-0.340)*	-0.013 (-0.103)*
Nine Oilseeds	0.074 (0.167)*	2.264 (2.077)	2.204 (10.184)	2.051 (3.263)	1.489 (2.880)	1.377 (13.672)
Groundnut	-0.56 (-0.981)	2.61 (1.672)	1.063 (3.471)	0.88 (1.180)	1.138 (1.010)	0.812 (6.832)
Rapeseed & Mustard	0.625 (1.036)	3.056 (2.175)	2.880 (8.479)	4.40 (5.881)	0.802 (0.795)*	2.072 (15.763)
Cotton	1.900 (4.186)	2.982 (2.678)	1.952 (5.700)	2.754 (4.209)	-1.75 (-2.144)	2.111 (19.290)
Potato	0.730 (1.454)	3.69 (3.774)	0.779 (10.551)	2.35 (6.655)	0.816 (2.820)	1.023 (24.816)

* Insignificant

Note: Figures in parenthesis are the respective t- values.

I. Pre-green revolution period
II. Green Revolution period
III. Post-green revolution period
IV. Pre-Liberalisation period
V. Liberalisation period
VI. Overall period

and tur. Value of D-W was close to 2 only in case of maize, whereas, it was 1.764 in case of wheat and more than 2 in case of grams and tur. Overall fit of regression was insignificant in case of tur and R^2 was equal to 0.117. In the rest of the equations of best fit, overall regression was significant.

Table 1 further revealed that out of competing functional forms CLG function was found to be best fit in case of bajra, rapeseed and mustard, cotton and potato. In case of all four crops, the individual regression coefficients were positive and significant. In case of all the crops except bajra, R^2 was very high. On the basis of F-statistics, it was found that overall fit of regression was significant.

In the case of groundnut, out of competing functional forms SLR was found to be best fit. In the case of the equation of best fit positive slope coefficient depicted a steady increase in the yield of groundnut. In case of groundnut, R^2 was equal to 0.485 and D-W was close to 2. Overall fit of regression as well as individual regression coefficients were found significant on the basis of tests of significance. It could be analysed from the aforesaid that a non-linear trend path was followed by all the crops, except groundnut.

Growth Performance

Measuring agricultural growth has been one of the most extensively researched areas. The growth rate analysis helps in evaluating development programmes, which were launched with specific objectives over a specific time span. A positive growth rate reveals an increase related aspect by its magnitude per annum, whereas vice-versa is case for negative growth rates. All the statistically non-significant growth rates indicate that there is no growth at all. Compound annual growth rates in respect of yield per hectare in case of 14 principal crop for overall (P) and sub-periods are shown in Table 2.

Perusal of Table 2 depicts that growth rate of productivity in case of food grains was 1.44% during PrGr and it increased significantly to 2.51% during GR

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and further showed acceleration to 2.74% during PoGr. For the overall period of 52 years, productivity of food grain grew at the rate of 2.33%. In case of PrGr period, productivity of rice increased at the rate of 1.86% and further showed an upsurge to 2.24 and 2.32% during GR and PoGr periods. For the overall period, productivity of rice registered a growth rate of 2.00%. Productivity of wheat followed an inverted U-path during the three sub-periods. During PrGr, it grew at the rate of 1.50%, achieved significant acceleration to 3.53% during GR period, and decelerated to 2.81% during the PoGr revolution. For the entire period of 52 years it grew significantly at the rate of 3.20%.

Productivity of wheat followed an inverted U-path during the three sub-periods.

Further, it could be analyzed from Table 2 that during PrGr, growth rate of yield per hectare of bajra was 1.44% and it decelerated to 1.25% during the GR and further picked up during the PoGR period and accelerated to 2.27%. For the overall period, productivity showed an acceleration of 1.93%. In the case of jute & mesta during sub-periods productivity showed continuous acceleration. It increased from 0.22% from PrGr to 1.28% during GR and further to 2.25% PoGr. For the overall period productivity of jute & mesta grew at the rate of 1.34%.

A further glance at Table 2 revealed that in the case of maize, total pulses and grams during the GR period, growth rates were negligible and insignificant. All this happened due to neglect of these crops and implementation of modern techniques of production in case of rice and wheat. In case of maize, productivity grew at the rate of 2.42% during the PoGr period and for the overall period of 52 years it increased significantly at the rate of 1.84%. In the case of total pulses negative growth of PrGr turned to be positive during GR and further accelerated to 0.86% during the PoGR period. For overall period, in case of total pulses, yield per hectare grew marginally at the rate of 0.53%. Productivity of grams followed the growth path similar to total pulses and showed a meagre growth rate of 0.79% for the entire period.

It can be further investigated that in case of tur (Table 2) negative growth of per yield during PrGr accelerated to 2.91% during the GR and decelerated steeply and turned negative (-0.27%) during the PoGr period. For the entire period of 52 years productivity of tur showed deceleration at the rate of -0.013. In the case of nine oilseeds yield per hectare showed continuous acceleration, it increased from 0.0774% during the PrGr period to 2.26% during GR period and showed marginal deceleration to 2.21% during the PoGr period. For the entire period of study yield per hectare accelerated at the rate of only 1.38%. In case of groundnut, during the PrGr period productivity depicted negative growth rate of 0.56%, but during the GR period growth rate turned positive and depicted a significant upsurge of 2.61%. The same growth path did not continue and it eclipsed to 1.06% during the PoGr period. For the overall period of 52 years yield of groundnut showed a marginal growth of 0.81%.

Further perusal of Table 2 conspicuously revealed that in case of rapeseed & mustard, cotton and potato, growth rates of yield depicted significant acceleration during the GR period as compared to PrGr period but growth rates significantly decelerated in case of cotton and potato during the PoGr period. In case of rapeseed mustard, yield per hectare depicted marginal deceleration during the PoGr period as compared to GR period. For the entire period yield per hectare increased significantly at the rate of 2.07%, in the case of rapeseed & mustard, whereas, in case of cotton and potato, growth figures were 2.11 % and 1.02%, respectively.

Impact of Liberalisation on Productivity

Perusal of columns 5 and 6 from Table 2 indicated that productivity of food grains increased at the rate of 2.66% during the pre-liberalization period and soared to 2.70% during the liberalisation period. In case of wheat, growth rate of yield that was 3.45% in pre- liberalisation moved down to 1.72% in the liberalisation period. In the case of rice, growth rates of yield followed a similar growth path as in wheat. Further perusal of Table 2 revealed that growth rate of yield of bajra, increased at the snail's pace of 0.57% in the pre-liberalisation period and moved up to 2.62% in the liberalisation period. In the case of jute & mesta yield per hectare which was 2.36% in the pre-liberalisation period decelerated to 1.44% in the liberalisation period. Growth rate of productivity in the case of maize was 1.97% during the pre-liberalisation period and accelerated to 2.49% during liberalisation, but in the case of total pulses, productivity demonstrated a trifling deceleration during liberalisation as compared to the pre-liberalisation period. The growth rate of yield per hectare of grams, which was negligible in the pre-liberalization period i.e. 0.20%, increased precipitously to 1.31% during the liberalisation period. It could be further analysed (Table 2) that in the case of tur, growth rate in terms of yield was 0.47% during the pre-liberalisation period but turned negative i.e. - 0.41% during the liberalisation period.

Compound annual growth rate of yield per hectare in the case of nine oilseeds increased at the rate of 2.05% in the pre-liberalisation period, depicted trivial deceleration in the liberalisation period when it reached the level of 1.49%. Growth rate of yield of groundnut moved up from 0.88% during the pre-liberalisation period, to 1.14% in the liberalisation period. Further perusal of Table 2 conspicuously revealed that growth rates of yield per hectare of rapeseed & mustard have shown precipitous deceleration from 4.40% during the pre-liberalization period to 0.81 % during the liberalization period. Yield per hectare of cotton increased at the rate of 2.75% in the pre-liberalization period but was replaced by a negative rate of growth of 1.75% in the liberalisation period. In case of potato, growth rate of yield per hectare decelerated significantly from 2.35% during the pre-liberalization period to 0.82% during liberalization period.

Policy measures and recommendations

In the years to come the policy makers will have to adopt strategic policy measures to enhance the productivity of Indian agriculture. Some of the policy measures as suggested through a number of other related studies are as follows:

- A system needs to be evolved to encourage contract farming with the participation of private companies. The private companies should be encouraged to provide technical know-how, supply of inputs, crop loans and a fixed contract price. Contract farming will result in minimizing the risk of farming and will help the farmers to take significant strides towards the acceleration of productivity.
- In order to compete globally, there is an urgent need to educate the farming community. State governments should sponsor regular visits of small farmers to advanced countries like Holland, China and Israel for acquiring new skills and techniques to enhance productivity. Through refresher training centres, awareness should be created amongst the farmers regarding critical operations like field preparing, planting and cultivating, and efforts must be taken at the right time, and very accurately, to maximize the land's productivity. Moreover, consciousness should be created amongst the farmers to start tiny processing units in their homes.
- Credit facilities provided by the government are not adequate and hence impede the growth of productivity. At present only about 6-7% of the working capital requirements for agriculture is met through institutional finance. Thus, there is an urgent need to provide timely and adequate credit at a cheaper rate than before, for increasing production and

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productivity. In addition to the above, there is a crucial need to channelise lending to agriculture by encouraging the establishment of an Agricultural Credit Corporation, to float tax-exempt saving bonds to persuade individual investors to deposit money, for providing direct loans to farmers. Moreover self-help groups need to be encouraged along with micro financing through private agents.

- Agricultural production depends on extensive as well as intensive cultivation but due to scarcity of land it largely depends upon intensive cultivation. In order to accelerate yield per hectare, we have to pay special attention to research & development and mechanization. Biological and chemical technology, scientific water management, high yielding varieties of seeds, improvement in cultivation and agronomic practices are needed to revitalize the slackened growth of productivity. Moreover, besides generating new technologies, strong and effective efforts are needed to transfer the existing technologies from the lab to the land.
- Productivity in the agricultural sector is greatly influenced by unpredictable random factors and natural calamities. In the wake of these uncertainties, there is an imperative need to guard the farming community by making the "National Agricultural Insurance Scheme" more effective and efficient. Moreover, the need of the hour is to work out a low premium insurance cover policy for crops along with price risk coverage.
- Keeping in view past trends of productivity and growth performance, we have to strengthen the policies and programmes for broadening further the base of agricultural growth and making it more sustainable. In this context, public investment should be enhanced to create rural infrastructure, re-orient research and extension work, complete a large number of irrigation projects, provide supply of inputs and high yielding varieties of seeds at cheaper rates and marketi support services. Moreover, there is a strong complementarity between public and private investment and, in order to trigger off private investment, a significant dose of public investment is prerequisite.
- Keeping in view the meagre rate of growth of

productivity of food grains and non-food grains during liberalisation, there is a need to take a fresh look at the potential of Indian agriculture and related policy measures should be taken to implement reforms in the agriculture sector on the lines of the industrial and service sectors. In order to achieve accelerated rate of growth of productivity, agriculture should be treated as industry and management support should be extended at all levels

- The analysis of the growth rate of productivity for the entire study period and sub-periods highlight that in case of most of the crops, the growth rate of productivity was not very much encouraging. In India we are facing the problem of yield as a barrier to the growth of agricultural output. We can substantially increase the yield per hectare with the help of biotechnology. Research in biotechnology coupled with traditional research methods, better agronomic practices and policies, may help reduce production risks by developing crop varieties that are drought tolerant, pest resistant and better in terms of nutritional content and may also help the farmers to increase productivity. The use of biotechnology will also reduce the risks from biotic and abiotic factors and environment degradation through promotion of sustainable use of natural resources and less use of fertilizers and pesticides.

Research in biotechnology coupled with traditional research methods, better agronomic practices and policies may help reduce production risks by developing crop varieties that are drought tolerant, pest resistant and better in terms of nutritional contents.

- The unregulated markets lead to the exploitation of farmers, the grower is deprived of a first-rate price for his produce during the peak marketing season, and the consumer needlessly pays a higher price during the lean season. The other problems include defective weightment, unfair grading and unfair deductions from sale proceeds. In order to motivate the farming community to realize the benefits of higher productivity, marketing infrastructure for agricultural produce should be augmented. In order to protect the farmer from selling at throwaway prices, capital subsidy schemes should be initiated for the establishment and expansion of storage facilities. Necessary infrastructure for rural markets should be developed to encourage the farmers to take agriculture as a commercial activity.
- In order to enhance the growth rate, researchers and scientists should be operationalised through the use of information technology. Through customized web portals in local languages farmers will easily access information on the local weather, best farm practices and expert advice. Advances in information technology will also help in the transfer of the knowledge base, technical information and new developments from developed country researchers to Indian agricultural researchers. All this will result in enhanced agricultural productivity and quality.
- In India small size of holdings act as a constraint to the growth of the agricultural sector. Due to the small size of holdings, it is not possible for the farming community to adopt scientific crop management, use new technology, efficient use of available resources and hence it loses on the front of reaping the economies of scale. In this context there is an urgent need for reforming Indian agriculture by corporatization of agriculture with a focus on improving efficiency and managerial practices, increasing production and productivity. In order to put corporatization of agriculture into practice, the state governments should provide necessary support; encouragement and assistance to the cooperatives and an Action Plan should be implemented by the central government for the same.

There is an urgent need for reforming Indian agriculture by corporatization of agriculture with a focus on improving efficiency and managerial practices.

- Agriculture in India is still viewed as a way of life and not as a full-fledged commercial activity. Semi-commercialization impedes the growth and results in low productivity. In order to transit from low productivity agriculture to high productivity agriculture, we have to change the outlook of our farmers to take farming as a commercial activity.

Concluding Remarks

From the curve fitting of ten distinct functional forms in case of fourteen crops, it has been observed that except groundnut, the non-linear path was followed for yield per hectare. PRB function was found to be the best-fit function in five cases, followed by CUB and CLG. SLR was found to be the best fit only in one case. Analysis of growth performance indicates that during

the three sub-periods crops have shown a different sort of growth behaviour. In case of certain crops like food grains, rice, wheat etc. growth rate of yield per hectare depicted continuous acceleration, whereas in the case of certain crops like groundnut, cotton etc. the growth path was an inverted U-shape. In case of a few crops like bajra, maize etc. growth rate of yield per hectare showed deceleration during the GR period and depicted acceleration during the PoGr period. During the liberalisation period performance of productivity represented the sad part of Indian agriculture as productivity of most of the crops not only decelerated but also turned negative. In the case of only a few crops growth rate of productivity showed a marginal upsurge. All this happened because during the reforms process central as well as state governments showed a lukewarm response to the agricultural sector. Past trends and analysis of growth performance underscore that for a better future we have to strengthen policies and programmes for further broadening the base for the agricultural sector.

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There is an urgent need to make collective efforts for improving the productivity of the Indian agricultural sector and steps taken in isolation will not yield the desired results. The need of the hour is to devise a well thought long-range strategy covering a package of initiatives as also legislation, wherever needed, to bring about a definite change in the agricultural scenario in the country. Such a package should lay emphasis on R&D efforts, development of a new variety of seeds, cutting costs, using time saving techniques and ensuring the entire agricultural enterprise is more efficient and accountable with a view to improve productivity. On the other hand, necessary efforts for the development of marketing infrastructure, effective crop management, training programmes, promotion of contract farming, strengthening of extension services, corporatization of agriculture and favourable public policy is necessary to improve productivity and efficiency and to compete in domestic and global markets. A significant improvement in yield per hectare will make Indian agriculture a rewarding profession for the tillers of the soil, comparable with the leaders at the world level.

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Feature

Mungbean cultivation in Punjab: Status, Potential & Constraints

D.K. Grover, Katinka Weinberger & S. Shanmugasundaram

Lax policy regarding food legumes and introduction of high-yielding, water-fertilizer responsive cultivars of paddy and wheat during the mid sixties has discouraged pulse cultivation, including mungbean, in favour of cereals in Punjab. The present paper studies the potential and constraints of mungbean cultivation in the state. The summer mungbean cultivation was an economically viable enterprise, there seems to be scope for its further expansion as an additional crop during the fallow period between wheat harvest and paddy transplantation in the cereal-fallow cropping system of the state. Regarding the replacement possibility of some area under paddy with mungbean during kharif season, there seems to be little scope at the existing level of yield and price of mungbean.

D.K. Grover is Deputy Director in charge, Agro-Economic Research Centre, Department of Economics, Punjab Agricultural University, Ludhiana, India. Katinka Weinberger and S. Shanmugasundaram are Socio Economist and Deputy Director General (Research) respectively, Asian Vegetable Research and Development Center–World Vegetable Center, Shanhua, Tainan 741, Taiwan, ROC.

Pulses occupy a very important position in Indian agriculture as they are leguminous and help restore the fertility of the soil. It is also the cheapest source of proteins that alleviate the problem of protein to some extent in our country where the majority of people are vegetarian. The per capita daily availability of pulses is much less in our country than the minimum requirements recommended by the nutritional experts. This is due to both the increase in population and decline in production of pulses in India over the years. Among the pulses, mungbean ranks third in production after Bengal gram (33 per cent share) and red grains (21 per cent share). Mungbean has 24 per cent easily digestible protein and the iron content is about 6 mg per 100 g dry seed. The fluctuations in area, yield and, hence, the production of mungbean crop in India and Punjab, in particular, over a long period of time, could be because more risks and uncertainties are involved both in terms of yield and price and, hence, the relative profitability of mungbean. India has been the net importer of 27,736 tonnes of mungbean worth Rs. 297 million (US $ 6.50 million) annually. Strengthening the domestic production of mungbean could save this burden on India's foreign exchange reserves. Keeping in view the land suitability and potential of mungbean crop, the important states to be concentrated upon are Maharashtra, Andhra Pradesh, Rajasthan, Orissa, Bihar, Karnataka, Madhya Pradesh and Punjab.

The rice–wheat based cropping systems (RWCS) in the agriculturally advanced state of Punjab has significantly contributed to enhancing the food production and achieving food self-sufficiency and food security. However, results of current studies bring out that the total factor productivity of dominant RWCS has either declined or stagnated. While legumes play an important role by providing organic matter in the sustainability of the system, ironically, rice-wheat has replaced legumes over a period of time.

Chatha and Singh (1983) suggested strong price

incentives and technology breakthrough in pulses. Sankhayan and Sood (1984) showed that the only pulse that showed some increase in production was mungbean by about 2.8 percent per annum from 1960-61 to 1980-81. Singh, Harjinder (1989) studied the production and marketing of pulses with mungbean as a separate pulse in Punjab and evolved policies for strengthening pulse production in general and that of mungbean, in particular, in the state.

The major reason responsible for the non-establishment of mungbean has been mungbean yellow mosaic virus (MYMV) causing severe yield losses. Another major factor that has limited mungbean's usefulness in the state of Punjab was the long duration of the traditional local cultivars. For want of short duration variety of mungbean, about 2.0 million hectares of Punjab in the RWCS remain fallow after the wheat harvest and before the rice planting. This fallow period is about 60-70 days (from mid April to end of June). However, the earlier mungbean cultivars mature in 80-90 days. Short duration mungbean is the only pulse crop that has potential to fit into this slot. To overcome the above constraints, Punjab Agricultural University and Asian Vegetable Research and Development Center have jointly developed new mungbean cultivar (SML 668–a selection from AVRDC line NM 94), which is high yielding, MYMV resistant/tolerant, synchronous maturity and short growth duration (65 days). This variety, unlike earlier varieties, has been found well adapted to both summer as well as kharif seasons. Incorporating such mungbean cultivars in RWCS helps sustain the natural resource base, enables the farmers to improve their household income, helps ensure nutritional security, diversifies their cropping system, and helps sustain the productivity of the farmland.

The purpose of the present study is to examine the possibilities for Punjab farmers to adopt and integrate MYMV resistant/tolerant, short duration mungbean cultivar (recently developed and recommended SML 668) in RWCS for diversification and sustainability of the cereal-based cropping system. The specific objectives of the present study are:

- To analyze the trends in area, yield and production of mungbean in Punjab
- To study the economic viability of summer mungbean cultivation
- To work out the relative economics of mungbean viz a viz its main competing crop in the kharif season.
- To examine the resource-use productivity of mungbean cultivation both in summer as well as kharif season
- To investigate major constraints to mungbean cultivation and solutions thereof

Methodology

To accomplish the various objectives of the study, both secondary as well as primary data were required. The secondary information, such as time series data on area, production, and yield of mungbean in Punjab were collected from secondary sources such as various publications of the Ministry of Agriculture, Statistical Abstracts of Punjab, Agricultural Statistics at a Glance, etc. To study the time trend and variability in different parameters of significance, Compound Growth Rate (CGR) and Coefficient of Variation (CV) were calculated for drawing better inferences and interpretations.

For primary data, the study covered most of the districts of Punjab. The sample constituted 108 mungbean growers spread all over the state. The mungbean growers were grouped into two categories as summer mungbean growers (75) and *kharif* mungbean growers (33). The required information and data pertaining to the parameters such as input use, costs, returns and production constraints etc were collected from these 108 sampled mungbean growers with the help of an especially designed schedule for the purpose. The survey was conducted during October-November 2002. The interpretations of data were based on simple tabular analysis. In addition, regression analysis was carried out to study the resource use efficiency in mungbean cultivation in the state.

Results and Discussion

The area, production and yield of mungbean, though fluctuating, showed an increasing trend over the years. The areas and production which was 3100 hectares and 1400 tonnes in 1965-66 rose to 52600 hectares and 43800 tonnes in 1995-96, respectively, before coming down to 29500 hectares and 18400 tonnes in

Table 1: Area, production and yield of mungbean in Punjab, 1965 through 2001

Year	Area (000 ha)	Production (000 tonnes)	Yield (kg/ha)
1965-66	3.1	1.4	451
1975-76	5.9	3.0	508
1985-86	46.4	41.3	890
1995-96	52.6	43.8	834
2000-01	29.5	18.4	624

Source: Statistical Abstract of Punjab, Various issues

Table 1(a): Compound Growth Rate and Coefficient of Variation in area, production and yield of mungbean in Punjab, 1965-2001

Period	Compound Growth Rate			Coefficient of Variation		
	Area	Prod.	Yield	Area	Prod.	Yield
1965-66/ 1974-75	8.743** (3.579)	10.854** (4.447)	1.609* (0.866)	44.77	51.13	8.27
1975-76/ 1984-85	34.506*** (7.048)	43.438*** (8.379)	6.646*** (0.884)	79.35	88.67	19.39
1985-86/ 1994-95	1.170 (1.258)	2.537 (2.596)	1.352 (1.975)	10.36	20.25	15.07
1995-96/ 2000-01	-8.171*** (1.469)	-17.054*** (2.551)	-9.687*** (2.376)	12.25	27.04	16.09
1965-66 /2000-01	10.625*** (0.968)	11.439*** (1.218)	1.561*** (0.286)	77.75	85.04	22.74

Figures within parentheses show the standard errors

*, **, *** Indicate the level of significance at 10, 5 and 1 per cent, respectively.

2000-01. The reason may be the declining yield of mungbean (from 890 kg/ha in 1985-86 to 624 kg in 2000-01) and absence of effective support price of mungbean in recent years (Table 1). The compound growth rates of area, production and yield of mungbean in Punjab highlighted that the period 1975-76 to 1984-85 was much more favorable for mungbean cultivation when area, and yield both increased at an annual rate of 34.50 and 6.64 per cent, but the reverse was true during the recent period of 1995-96 to 2000-2001 when area and yield declined by 8.17 and 9.68 per cent respectively, resulting in the contraction of production by 17 per cent per annum. Though positive and statistically significant growth rates in area, production and yield of mungbean were found in the state over the period 1965-66 to 2000-01, yet the severe variability (coefficient of variation) in area, production and yield of mungbean was noticed in Punjab over the corresponding years. The coefficient of variation has been found to be 77.75, 85.04 and 22.74 per cent, respectively, indicating that mungbean has never been a stable crop in the state. (Table 1a).

Economics of Mungbean Cultivation

Human labour/machine input use: Human and machine labour are the basic inputs required for producing any farm commodity. The operation–wise per hectare use of human labour (family and hired) and machine labour (owned and hired) for the cultivation of mungbean has been given in Table 2 and Table 3 respectively. It can be seen from Table 2 that on an average, 237 and 278 human labour hours were utilized per hectare for the cultivation of mungbean in summer and kharif seasons, respectively. The major operations in order of importance were harvesting, weeding/hoeing and irrigation that required 88.5, 49.5, and 42.1 man hours/hectare, respectively, for summer mungbean and 85.9,86.1 and 51.6 for kharif mungbean cultivation. It is also seen that the summer mungbean growers depended more on hired human labour for farm operations as compared to kharif mungbean growers. The total cost incurred for human labour input/hectare of mungbean cultivation has been estimated as Rs 2371 and Rs 2785 for summer and kharif mungbean, respectively. Table 3 shows that the average use of machine hours per hectare of mungbean cultivation was 8.23 and

Table 2: Human Labor use (hours/hectare) in mungbean cultivation on sample farmers, Punjab, 2002

Operations	Mungbean Growers							
	Summer				Kharif			
	Family	Hired	Total	Value (Rs)	Family	Hired	Total	Value (Rs)
Field preparation	3.8	2.5	6.3	63.0	5.6	2.4	8.0	80.30
Seed sowing/planting	2.7	2.7	5.4	53.9	2.4	2.2	4.6	45.64
Fertilizer application	2.5	2.6	5.2	51.5	4.3	2.3	6.6	66.29
Farm yard manure	0.0	0.3	0.3	0.0	3.3	0.0	3.3	33.33
Weeding/Hoeing	1.9	47.5	49.5	494.7	22.6	63.6	86.1	861.36
Insecticide/pesticide application	2.4	5.3	7.6	76.3	7.4	2.9	10.3	103.41
Herbicide application	0.9	2.1	3.1	30.5	1.7	0.9	2.6	26.14
Irrigation	24.1	18.0	42.1	420.7	37.1	14.5	51.6	515.91
Harvesting	3.3	85.1	88.5	884.5	9.9	76.0	85.9	859.09
Threshing/winnowing	7.4	16.4	23.8	239.2	9.5	3.6	13.1	131.06
Sorting/ marketing	5.7	0.0	5.7	56.5	5.8	0.4	6.2	62.12
Total	54.7	182.5	237.5	2370.8	109.6	168.8	278.3	2784.65

Source: Socio-economic sample survey, 2002.

Table 3: Machine use (hours/hectare) in mungbean cultivation on sample farmers, Punjab, 2002

Operations	Mungbean Growers							
	Summer				Kharif			
	Owned	Hired	Total	Value (Rs)	Owned	Hired	Total	Value (Rs)
Field preparation	3.63	0.28	3.91	683.81	3.86	0.30	4.16	728.44
Seed sowing/planting	2.26	0.27	2.53	885.50	2.41	0.32	2.72	952.88
Farm yard manure	0.1	0	0.10	14.58	0.00	0.00	0.00	0.00
Threshing/winnowing	0.53	0	0.53	107.33	0.74	0.38	1.12	195.55
Sorting/ marketing	1.16	0	1.16	208.54	0.61	0.00	0.61	106.06
Total	7.68	0.55	8.23	1899.76	7.62	1.00	8.61	1982.93

Source: Socio-economic sample survey, 2002.

Table 4: Physical input use per hectare of mungbean cultivation on sample farmers, Punjab, 2002

Items	Mungbean Growers							
	Summer				Kharif			
	Quantity			Value (Rs)	Quantity			Value (Rs)
	Home	Market	Total		Home	Market	Total	
Seed (Kgs)	5.5	20.5	26.0	785.4	4.9	19.1	24.0	662.3
Urea (Kgs)	0.0	24.2	24.2	106.1	0.0	47.9	47.9	209.6
SSP (Kgs)	0.0	61.6	61.6	183.6	0.0	18.9	18.9	56.4
DAP (Kgs)	0.0	8.9	8.9	79.5	0.0	45.1	45.1	401.2
FYM/ash	0.1	0.0	0.1	10.0	0.0	0.0	0.0	0.0
Insecticides/ pesticides (Rs)	0.0	Multiple	0.0	511.7	0.0	Multiple	0.0	777.4
Herbicides(Rs)	0.0	Multiple	0.0	423.0	0.0	Multiple	0.0	304.9
Petrol/Diesel(lt)	0.0	0.7	0.7	13.9	0.0	1.4	1.4	24.4
Irrigation*(no.)	0.0	4	4	20	0.0	3.0	3.0	20
Total (Rs)				2133.3				2456.2

Source: Socio-economic sample survey, 2002.

* These are only canal irrigation charges. The Government of Punjab gave free electricity to the farmers for irrigation.

8.61 for summer and kharif season, respectively. The machines were mainly used for field preparation and seed sowing /planting operations. These two operations required 3.91 and 2.53-machine hours/hectare, respectively, for cultivation of mungbean in summer season and 4.16 and 2.72 for kharif season. The summer mungbean growers used more of their own machinery and had comparatively less dependence on custom hiring machines in relation to the kharif mungbean growers. The total cost involved for machine use/hectare was Rs 1900 and Rs 1983 for summer and kharif mungbean, respectively.

Non–labour inputs: The average use of various physical inputs for mungbean cultivation in summer and kharif seasons have been demonstrated in Table 4. The seed rate recommendation is 25 kg per hectare for the spring/summer crop varieties SML 134 and SML 32, 37 kg per hectare for SML 668 and 20 kg for the kharif season crop. The actual seed rate per hectare at the farmer's level was observed as 26 kg and 24 kg for summer and kharif seasons, respectively. The low seed rate was used for summer mungbean and higher for kharif mungbean cultivation in relation to the respective recommendations. The use of urea fertilizer per hectare was 24.2 and 47.9 kg for summer and kharif mungbean cultivation, respectively, as against the recommendation of 27.5 kg. The super phosphate input was applied much less than the recommendations of 250 kg per hectare. The average number of irrigations, i.e. four for summer mungbean and three for kharif mungbean, were found in line with the recommendation of 3-5 irrigations for summer mungbean depending upon the climatic conditions and water holding capacity of the soil. Irrigation is required for the kharif

season crop if the rain fails. The plant protection material used by the mungbean growers was much less than its recommendation.

Relative share of various inputs/ factors: The relative share of various inputs/factors in the total cost of cultivation of mungbean has been worked out and the same has been shown in Table 5. The table showed that the land rent was the major single component, which constituted about 43 and 46 percent of the total cost of cultivation for summer and kharif mungbean, respectively. The other important factor was human and machine labour required for all the farm operations of mungbean. The share of these factors taken together accounted for about 37 and 35 per cent of the total cost of production during the summer and kharif seasons. The share of seed was relatively more (6.82 per cent) for summer mungbean as compared to 4.80 per cent in the kharif season. On the other side, the relative share of fertilizers was found to be less (3.29 per cent) in relation to kharif mungbean (4.83 per cent). The plant protection material (insecticides/pesticides and herbicides) constituted about 8 per cent of the total cost of production both for summer and kharif seasons.

Table 5: Relative share (%) of various inputs/ factors in the total cost of production of mungbean on sample farmers in Punjab, 2002

Inputs/factors	Mungbean Growers	
	Summer	Kharif
Human labour	20.59	20.17
Machine labour	16.50	14.36
Seeds	6.82	4.80
Fertilizer/ Farm manure	3.29	4.83
Irrigation	0.17	0.14
Insecticides/pesticides	4.44	5.63
Herbicides	3.67	2.21
Petrol/Diesel	0.12	0.18
Interest on variable cost@14%	1.62	2.14
Land rent	42.75	45.55
Total cost	100.00	100.00

Yield of mungbean: The average realized grain yield of summer and kharif mungbean crops at the farmers' field was found as only 654 kg and 695 kg per hectare, respectively, during the year under study (Table 6). The average grain yield of SML 668 in the research trials was 1200 kg and in the adaptive research trials it was 1113 kg per hectare. Similarly, ML 613 yielded 1325 kg and, 1263 kg per hectare in research and adaptive trials, respectively, in the kharif season. The realized yield of mungbean by farmers was found to be just 50-60 per cent of the potential yield in the adaptive research trials.

Table 6: Yield and value of mungbean production per hectare on sample farmers, Punjab, 2002

Items	Mungbean					
	Summer			Kharif		
	Qty (Kg/ha)	Price (Rs/kg)	Value (Rs)	Qty (Kg/ha)	Price (Rs/kg)	Value (Rs)
Main product	654.42	19.30	12631.05	695.46	20.64	14351.41
By product	217.67	0.52	112.13	344.16	0.61	211.20
Total	872.09		12743.18	1039.61		14562.61

Source: Socio-economic sample survey, 2002.

Benefit-cost analysis: In order to estimate the cost of production of mungbean, the various inputs purchased from the market were valued at the actual price paid by the farmers and the home produced inputs like seed and farmyard manure etc were estimated at the prevailing market prices for such inputs in the local market in a particular area. The family labour and owned machine used at the farm were assessed at the ongoing wage rate for hiring casual labour and the prevailing custom hiring charges for such machines during the survey period. The interest on the total variable cost was taken @14 percent per annum for half of the crop period. The land rent was included for 75 days in case of summer and 105 days for kharif mungbean cultivation, keeping in view the prevailing annual land rent for similar land in the area as perceived by the farmers. The total output of both the main product as well as the by product was evaluated at the market prices, actually realized by the farmers. The total cost included human labour (family +hired) for all the farm operations, machine labour (owned + hired) for all the farm operations, seed (farm produced+ purchased), fertilizers, farm manures, irrigation charges, plant protection material (insecticides/pesticides + herbicides), petrol/diesel, interest on the variable cost @14 per cent per annum for half of the crop period and the land rent for 75 days in case of summer mungbean and 105 days for kharif mungbean cultivation. The gross income per hectare of mungbean cultivation has been estimated by multiplying the per hectare production of the main product and by product with their respective post harvest period prices. The net income has been calculated by deducting total cost per hectare from the gross income per hectare. The cost per unit of main output has been worked out by deducting the gross income of the by product from the total cost and then dividing it by the total yield of the main product. The benefit-cost ratio is simply obtained by dividing

the gross income per hectare by the total cost per hectare of mungbean cultivation.

· The gross income from per hectare production of summer mungbean and kharif mungbean was Rs 12742 and Rs 14565. The respective total costs of cultivation per hectare were Rs 11513 and Rs 13808, leaving only Rs 1230 and Rs 758 as net income from summer mungbean and kharif mungbean respectively (Table 7). The cost of production (Rs/ kg of grains) was lower (17.42) for summer mungbean in relation to 19.55 for kharif mungbean. Similarly, the benefit–cost ratio was also found higher (1.11) in case of summer mungbean as compared to only 1.05 for kharif mungbean cultivation. The returns over variable costs (ROVC)/hectare from summer mungbean and kharif mungbean were found to be Rs 6152 and 7047, respectively, during the year of study.

Table 7: Benefit – cost analysis of mungbean and paddy cultivation/hectare on sample farmers in Punjab, 2002

(Rs/ha)

Particulars	Mungbean		Paddy
	Summer	Kharif	
Human labour	2370.7	2784.65	2871.72
Machine labour	1899.76	1982.93	3881.03
Seeds	785.4	662.3	177.06
Fertilizer/ manure/ zinc sulphate	379.2	667.2	2123.52
Irrigation	20	20	20
Insecticides/pesticides	511.7	777.4	935.185
Herbicides	423	304.9	550.7
Petrol/Diesel	13.9	24.4	990.763
Interest on variable cost @14%	187	295	353.204
Land rent	4922	6289	11812.8
Total cost	11512.7	13807.8	23715.95
Yield (Kg/ha)-Main product	654.42	695.46	5741.25
Price (Rs/kg)-Main product	19.3	20.64	5.52
Value of by-product	112.13	211.2	0
Gross income	12742.4	14565.5	31691.7
Returns over variable cost	6151.78	7046.72	19788.55
Net income	1229.78	757.72	7975.75
Benefit-Cost ratio	1.11	1.05	1.33
Cost per unit of output (Rs/kg)	17.42	19.55	4.13
Desired yield to compete with paddy	654.42 + 175	695.46 + 175	

Source: Socio-economic sample survey, 2002.

Table 8: Resource use efficiency of mungbean cultivation on the sample farmers in Punjab, 2002

Variable	Symbol	Unit	Regression Coefficients	
			Summer Mungbean	Kharif Mungbean
Intercept	a0		-29.6367 (161.2437)	1077.86*** (535.2049)
Human labour	x1	Hours	-0.19627 (0.4147)	-0.8421 (1.4401)
Machine labour	x2	Hours	19.2266 *** (6.6016)	-16.9570 (20.7277)
Seed	x3	Kg	20.8403 **** (4.14287)	-4.6509 (15.2433)
Urea	x4	Kg	1.1848 (0 .9859)	-0.9871 (1.7092)
SSP	x5	Kg	-0.1668 (0 .2793)	1.2738* (0 .8091)
MOP	x6	Kg	-1.2409 (1.1905)	2.9838* (1.8680)
DAP	x7	Kg	-0.0221 (0.0594)	-0.128962 (0 .1848)
Insecticide/ pesticides	x8	Rs	0.10361** (0 .0544)	0.2670** (0 .1473)
Herbicides	x9	Rs	-17.8701 (9.7001)	10.1371 (13.8968)
R-SQ. (F – Ratio)			0.4836 (6.76)	0.3010 (1.10)
No. of observations			75	33

The figures with in parentheses show the respective standard error of coefficient.

****, ***, **, *: Show the significance at 1%, 5%, 10%and 15% levels respectively.

Comparative economics of mungbean and paddy: Mungbean crop that occupied only 3100 hectares in 1965-66 increased consistently to 54900 hectares in 1994-95. However, during recent years, the area under mungbean has been declining and reached a level of 29500 hectares in 2000-01. This decline may be mainly because of the lower comparative economics of this crop. Table 7 further shows that the ordinary rice crop promised returns over variable costs of Rs. 19789 /hectare, which was much higher than what farmers got from the mungbean crop. Mungbean (summer and kharif taken together) yielded returns over variable costs of Rs.13199 per hectare during the year of study, which was much less than that of rice. The gap between the ROVC between the two-mungbean crops (summer + kharif) and the competing crop, paddy, has been observed as Rs 6590 per hectare. In order to replace the paddy crop with these two mungbean crops in the state, either the prices of mungbean should be increased, at least, by 25 per cent or the yield of mungbean. In a market driven set up, the prices of any product cannot be kept artificially high for a long time;

therefore, the only alternative available is to enhance the yield of mungbean at the farmer's field.

The realized yield of mungbean by farmers was found to be just 50-60 per cent of the potential yield in the adaptive research trials as against as high as about 85 per cent in the case of paddy. This big gap between the potential and realized yields of mungbean brings out that there is an urgent need to strengthen further the agricultural extension wing of the state to disseminate effectively, the available farm technology of mungbean production to farmers, the ultimate users. Similarly, till the present time the minimum support price of mungbean has been just about one-half of the post harvest market price, showing that the price support given to this crop is non-existent. The mungbean is, of course, a low human labour and machine labour input crop. For one-hectare cultivation of summer mungbean, the human labour and machine labour was utilized for 237.5 hours and 8.23 hours, respectively, and for kharif mungbean these figures were 278 and 8.61 only as against 438 human labour hours and 30 machine labour hours for paddy cultivation. Even the requirements of mungbean in terms of other inputs like fertilizer, irrigation etc. is much lower as compared to paddy - a high input crop. In the pockets where green revolution has left its real impact, the farmers are interested in adopting the profit maximizing crops rather than resource saving crops.

Input–use–Efficiency of Mungbean Cultivation

Yield response function–Regression Analysis: In order to study the yield response (resource –use- efficiency) of summer and kharif mungbean, Cobb-Douglas production function (Power function) and Linear production function were tried taking the dependent variable (Yield of mungbean/hectare) and various independent variables like human labour, machine use, seed, fertilizer, insecticides/pesticides, fertilizers, herbicides etc. both in terms of quantity (kgs, litres or hours/ hectare) as well as value (Rs/ hectare), separately, for summer and kharif mungbean. The following linear regression model was found to be a better fit in terms of the value of coefficient of multiple determination, level of significance and logical signs of different independent variables for summer as well as kharif mungbean crops:

$$Y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + a_6x_6 + a_7x_7 + a_8x_8 + a_9x_9 + u$$

Where,

Y = Yield of mungbean grain (kg/ hectare)

x_1 = Human labour (Hours/hectare)

x_2 = Machine labour (Hours/hectare)

x_3 = Seed(kg/ hectare)

x_4 = Urea fertilizer (kg/hectare)

x_5 = SSP fertilizer (kg/hectare)

x_6 = MOP fertilizer (kg/hectare)

x_7 = DAP fertilizer (kg/ hectare)

x_8 = Insecticide/pesticides (Rs/hectare)

x_9 = Herbicides (Rs/hectare)

a_0 = Intercept

a_i's = Regression coefficients of respective independent variables

u = Error term

The function was estimated using the OLS method and the results have been presented in Table 8. The results brought out that in case of summer mungbean, the regression coefficient of seed was positive (20.8403) and significant at 1 per cent level, which implied that with an increase of seed by 1 kg, the resultant yield would increase by 21 kg per hectare. Similarly, the positive and significant (5 per cent level) coefficient of machine labour showed that the additional 1 hour use of machine labour would enhance the yield by 19 kg per hectare. The coefficient of insecticides/pesticides (0.10361), which has been found statistically significant at 10 per cent level, indicated that the additional spending of Rs 100 on this variable would result in an increase of yield of mungbean by 10.36 kg per hectare. The value of R-SQ. (0.4836) found in case of summer mungbean showed that all the independent variables included in the model, taken together, explained about 48 per cent of variation in the dependent variable (Yield /hectare). The remaining variation may be due to those factors that have not been captured in the model. In case of mungbean crop in the kharif season, the value of R-SQ was observed as 0.3010, implying that about 30 per cent variations in the yield of mungbean could be explained by these explanatory variables, taken together. The coefficients of explanatory variables viz., SSP and MOP, were found to be positive and statistically significant at 15 per cent level, showing further scope of enhancing the yield of mungbean per hectare by increasing the dose of these inputs. Similarly, the coefficient of insecticides/pesticides (0.2670), which has been found statistically significant at 10 per cent level, brought out that the additional spending of Rs 100 on this variable would result in an increase of yield of mungbean by 26.70 kg per hec-

Table 1: Growth Trend in Area, Production and Yield of Soybean (1981-82 through 1991-92 and 1991-92-2001-02)*

State	Particular	1981-82 through 1991-92			1991-92 through 2001-02			1981-82 through 2001-02
		B_0	b_1	CGR (%)	b_0	b_1	CGR (%)	CGR (%)
M.P.	Area	409.1	1.187	18.7	2810.2	1.051	5.1	12.4
	Production	268.3	1.214	21.4	2682.0	1.048	4.8	14.5
	Yield	656.0	1.023	2.3	954.4	0.997	-0.3	1.9
Maharashtra	Area	6.5	1.408	40.8	200.0	1.277	27.7	29.6
	Production	1.0	1.668	66.8	218.4	1.270	27.0	34.9
	Yield	148.3	1.185	18.5	1091.7	0.990	-1.0	4.2
Rajasthan	Area	8.3	1.363	36.3	228.0	1.110	11.0	23.1
	Production	1.4	1.438	43.8	264.7	1.088	8.8	25.9
	Yield	1.1	1.055	5.5	1160.9	0.979	-2.1	2.2
Gujarat	Area	8.6	1.075	7.5	24.4	0.868	8.7	-2.66
	Production	2.9	1.166	16.6	17.1	0.879	8.8	0.8
	Yield	338.9	1.085	8.5	699.5	1.012	1.2	3.6
Karnataka	Area	1.9	1.284	28.4	33.0	1.077	7.7	13.4
	Production	0.9	1.302	30.2	18.8	1.127	12.7	18.6
	Yield	476.2	1.014	1.4	570.4	1.047	4.7	4.6
India	Area	559.6	1.169	16.9	3398.4	1.070	7.0	13.0
	Production	363.0	1.199	12.0	3248.5	1.073	7.3	15.6
	Yield	648.5	1.025	2.5	956.0	1.004	0.4	2.3

* Base year (t = 1) is 1981-82 for all the states except for Karnataka and Maharashtra for which it is 1985-86. Units of Area, Yield and production are 000'ha, kg/ha, and 000'tonnes, respectively.

data. The primary data were obtained through Participatory Rural Appraisal (PRA) of major soybean growing districts of Maharashtra and Madhya Pradesh by a multidisciplinary team comprising of experts from different agricultural disciplines, few state government officials of Maharashtra and Madhya Pradesh and representatives of Soybean Processors Association of India (SOPA) in October 2000. Time series data on state-wise area, yield and production of soybean was collected from various issues of CMIE reports, SOPA publications and publications of the Government of India.

The growth in area, production and yield of soybean was fitted at a compound rate of growth given as follows:

$$Y = b_0 (b_1)^t \qquad ...(i)$$

Where, b_0 is intercept, b_1 is $1+r$; r being the compound rate of growth (CGR). CGR in per cent is computed as $(b_1-1) \times 100$.

Computation of sources of growth was based on the method suggested by Sharma (1977). This method decomposes total growth in production into three components – yield effect, area effect and yield-area interaction effect. It is given as:

$$\Delta Q = A_0 \Delta Y + Y_0 \Delta A + \Delta A \Delta Y \qquad ...(ii)$$

Where, A_0 denotes initial area, P_0 denotes initial production and Y_0 indicates initial yield in the base year. ΔA and ΔY indicate change in area and change in yield, respectively, between the based year and the nth year. The first component of the right hand side of the equation (ii) indicates yield effect, second term indicates area effect and third term is the interaction effect of production change. The analysis was done with the time series data on area, production and yield of soybean for five major soybean producing states, namely, Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Gujarat as well as for the country as a whole. These states together account for 99 per cent of soybean production of the country. In order to smooth out yearly fluctuations due to weather conditions, three-yearly averages centered around the base and terminal year were used.

Table 2: Decomposition of Growth in Production of Soybean in India (1981-82 through 2001-02)*

State	Period I (1981-82 through 1991-92)				Period II (1991-92 through 2001-02)			
	Change in Production (%)	Area Effect (%)	Yield Effect (%)	Interaction effect (%)	Change in Production (%)	Area Effect (%)	Yield Effect (%)	Interaction effect (%)
Madhya Pradesh	621.3	77.8	3.8	18.4	46.3	129.1	-18.2	-10.9
Maharashtra	661.7	42.9	14.9	42.2	1121.2	120.5	-7.4	-19.2
Rajasthan	3921.1	54.2	2.1	43.7	100.5	197.0	-32.6	-64.4
Gujarat	224.1	26.4	46.3	27.3	-65.0	98.41	4.4	-2.8
Karnataka	190.4	83.7	6.3	10.0	207.8	49.3	25.0	25.6
India	557.8	74.4	5.0	20.6	83.1	107.9	-4.2	-3.7

* Base year (t = 1) is 1981-82 for all the states except for Karnataka and Maharashtra for which it is 1985.86.

Table 3: Average Area and Yield of Soybean at the Sample Households*

District	No. of sample farmers	Cultivated Land Holding (Ha)	Area under Soybean (Ha)	Per cent Area under Soybean	Average Yield (Qtl./Ha)	Maximum Yield Attained (Qtl./Ha)
Sangli	38	4.80	1.91	40.55	29.47	37.50
Kolhapur	22	3.76	1.61	38.46	22.84	32.33
Akola	9	9.38	1.89	28.06	14.58	25.00
Amarawati	8	13.68	3.49	32.36	17.85	29.64
Nagpur	4	7.00	4.30	62.19	17.50	25.00
Maharashtra	81	7.72	2.64	40.32	20.45	29.89
Betul	4	17.20	9.80	60.63	15.00	20.11

Results and Discussion

Soybean production at the commercial level started in the sixties. However, the phenomenal growth in its area and production took place only during the eighties. This became possible due to simultaneous growth in the processing capacity of soybean in Madhya Pradesh, Maharashtra and few other states. Billore and Joshi (1998) have examined growth trends in area, production and productivity of soybean across states up to the year 1993-94. However, the present study has made use of available data up to 2001-02. The whole period under study (1981-82 through 2001-02) has been divided into two sub- periods – period I (1981-82 through 1991-92) and period II (1991-92 through 2001-02). Estimates of compound growth rates have been presented in Table 1. It can be seen that growth rate in area, production and yield was much higher in the period I as compared to period II. The yield almost stagnated during the period II.

The relative contributions of area, yield and area-yield interaction towards soybean production has been given in Table 2. Madhya Pradesh, Maharashtra and Rajasthan are major producers of soybean and any change in the production scenario of these states will have a significant influence on soybean production at the national level. It can be seen from the table that contribution of area expansion (74.4%) has been the most important factor in soybean growth at the national level and invariably across states. The contribution of yield (5.0%) has not been so impressive during this period. However, in the following decade, growth in soybean production has come from area expansion, in fact, with yield going down marginally. With competing uses and burgeoning population, area expansion under soybean is a real limiting factor. Therefore, the only feasible alternative for increasing soybean production is to increase its yield. This can be achieved either by increasing the yield through research and/or through minimising the yield gap between actual yield and achievable yield. The first option has been examined by Lal and Rana (2000) and Tiwari (2002). In the following section, we will discuss the second alternative i.e. how to minimise the yield gap in soybean.

Average yield and production practices across different regions of MP and Maharashtra are presented in Table 3 and Table 4, respectively. The aforesaid survey

Table 4: Seed Rate, Seed Price and Seed Source for Soybean Cultivators

(Per cent of farmers)

Particulars	Maharashtra	Madhya Pradesh
Seed Rate (Kg/ha)	73.15	84.90
Price of Seed (Rs/Kg)	17.82	16.5
Source of Seed		
Co-operative Society	80	20
Private Trader	14	23
Research Institute	6	26
Own	–	29
Other Farmers	–	2
Seed Treatment		
Treated with *Rhizobium* culture	55	87
Treated with Phosphate Solubilising Bacteria (PSB)	29	61
Treated with fungicide	26	61
Method of Seed sowing		
Seed Drill	31	100
Manual Dibbling	69	0
Major Varieties Grown by Farmers		
JS-335	74	66
PK-472	5	2
MACS-13	8	3
Samrat	0	10
Pusa-16	0	2
JS 71-05	1	0
NRC-12	0	3
Others	12	14
Frequency of Purchase of New Seed by Farmers		
Every year	76	34
Every two years	17	26
Every three years	7	31
More than three years	0	9

covered 11 districts and elicited information regarding different aspects of soybean cultivation from 120 farmers of both the states. It was found that the average cultivated area and percentage of area under soybean were greater in MP as compared to Maharashtra. Sangli and Kolhapur regions were more irrigated and fertile but land holdings were small. However, it was the yield of soybean in these two regions, which was interesting. The average yield in Sangli was found to be 29.47 qtl/ha while the same was 22.84 qtl/ha in Kolhapur. It was noticed that soybean was grown with a heavy dose of inputs and manual operations in these two districts. The average yield in Maharashtra (20.45 q/ha) was found to be 53 per cent higher than that in MP (13.34 qtl/ha).

In Maharashtra, a major source of seed was cooperative societies which have strong linkages with state level seed suppliers e.g. Mahabeej. Approximately 76 per cent of Maharashtra farmers and only 34 per cent of MP farmers bought seed from the market every year. Manual dibbling was found to be the dominant method of sowing in Maharashtra, on the contrary, almost all the sowing was done with seed drills in MP. Farmers of MP were found to be more innovative with respect to treatment of seeds with *Rhizobium* culture, phosphate solubilising bacteria (PSB) and fungicide. However, JS 335 was found to be the dominant variety in both the states. The level of mechanization in soybean cultivation was observed to be greater in MP (Table 5).

In Maharashtra, a major source of seed was cooperative societies which have strong linkages with state level seed suppliers.

Table 5: Level of Mechanization in Soybean Cultivation

(Per cent of farmers)

Particulars	Maharashtra			Madhya Pradesh		
	Tractor	Bullock	Manual	Tractor	Bullock	Manual
Land Preparation	83	17	0	90	10	0
Sowing	6	21	73	72	15	13
Harvesting	0	1	99	10	3	87
Weed Control	0	0	100	5	3	97

Estimates of Yield Gaps

The yield gap is the difference between the potential yield and actual yield (Gomez et al., 1979). Yield gap I is the difference between experimental station yield and potential farm yield. It exists mainly because of environmental differences between experimental differences between experimental station yield and potential farm yield and because of environmental differences between experiment stations and the actual growing conditions on the farmer's field. In the present study the highest yield reported under the advanced varietal trial (AVT) of

the All India Coordinated Research Project on Soybean (2001-2002) was taken as the experimental yield and average yield of the best performing variety for a particular zone under AVT was taken as the "average yield in on-farm experiments" as a measure of potential farm yield. Yield gap II is the difference between the "average yield in on-farm experiments" and the actual farm yield. This gap reflects biological constraints, soil and water constraints and socio-economic constraints that compel framers to use inputs at a level below the technical optimum. A part of yield gap II could be reduced through research for developing resistance in soybean cultivars against various biotic and abiotic stresses and through appropriate socio-economic policies. Actual farm yield was obtained from the survey data. Results of the yield gap analysis are given in Table 6.

Table 6: Estimates of Yield Gaps between Experimental Yield and Farm-level Yields (2001/2002)

Variables	Maharashtra (kg/ha)	Madhya Pradesh (kg/ha)
Highest Experimental Yield	3597	2330
Average Yield in On-farm Experiments	2160	1940
Average Farm Level Yield	2045	1334
Yield Gap I (per cent)	70.26	29.23
Yield Gap II (per cent)	5.62	45.42

Table 7: Major Constraints to Higher Yield as perceived by Farmers

(Per cent of responses)

Constraints	Maharashtra	Madhya Pradesh
Diseases	41	19
Incidence of Insect-pests	24	29
Weeds	16	17
Drought and Erratic Rainfall	15	31
Poor Seed Quality	2	3
Others	2	1
Total Number of responses	127	80

*Others include low soybean price and labour scarcity

In Maharashtra the yield gap I was found to be 70 per cent of farm level yield whereas, the same for MP was 29 per cent. Yield gap II was found to be 5.62 per cent in the former whereas it was 45.4 per cent for the latter. It shows that even at the current level of technology soybean production can be increased to a significant percentage through an integrated approach to achieve efficiency in production. Major constraints to higher yield as perceived by farmers are given in Table 7. Diseases and incidence of insects-pests were found to be the most severe problems in Maharashtra whereas drought and erratic rainfall and incidence of diseases were found to be the most severe constraints to higher productivity in MP.

Conclusion

The study revealed that 74 per cent of increase in soybean production during the eighties came from increase in area while yield and area-yield interaction effects contributed towards 5 and 21 per cent, respectively. But during the nineties, area expansion was the only factor leading towards growth in production; yield being a non-contributor. However, cultivable land being a highly scarce resource, further growth in soybean production has to come from yield increases. This would require development of stress tolerant varieties as well as plugging of yield losses and inefficiencies in input use at the farm level. Yield gap II was found to be 5.6 per cent in Maharashtra and 45 per cent in MP in comparison to current level of farm yields. Addressing farm level constraints to yield increase can bridge this gap.

Diseases which affect soybean crop are rust, sclerotuim rot, rhizoctonia root rot, bacterial pustules, myrothecium leaf spot, soybean mosaic, yellow mosaic, alternaria leaf spot and bud blight. The rust caused by *Phokospara pachyrhizi*, which was earlier confined to pockets of northern hills, has now assumed serious proportions in parts of MP, Maharashtara and Karnataka (Tiwari, 2002). Similarly, yellow mosaic was observed to be spreading at a very fast pace in Bhopal and Hoshangabad regions of MP. This warrants prompt disease management interventions to avert any epidemiological spread. Major insects-pests of soybean were found to be girdle beetle, green semi-loopers, hairy caterpillar, pod borer, leaf minor and white fly. Monitoring of these pests and transfer of integrated pest management (IPM) technology to farmers should be accorded high priority. Similarly, an integrated approach to weed management at the farm level will help bridge the yield gap II. Further, efficient utilisation of water would be critically important to increase the soybean and soybean-based production system. This should be in the form of *in situ* water conservation practices, and optimum irrigation scheduling. Extension agencies need to create awareness about suitable methods for this purpose. Finally, ensuring supply of good quality seeds, assured price and a

higher level of mechanization will go a long way in increasing soybean productivity and production.

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Only as long as a company can prouce a esired, worthwhile, and needed product or service, and can command the public, will it receive the public dollar and succeed.

– Curtis Carlson

Feature

Inefficiency in Rice Production: Sone Command Area of Bihar

A.R. Reddy, C. Sen & R.R. Mishra

Three types of inefficiencies i.e., economic inefficiency, and allocative inefficiency in rice production in the Sone canal command area of Bihar (India) were estimated in this study. Frontier function approach was used to estimate inefficiency. Functional analysis revealed that area, fertilizers, plant protection chemicals, bullock labour and machine labour were underutilized in rice production while human labour was used in excess quantity. Results revealed that economic inefficiency was 51.59 per cent, technical inefficiency was 25.55 per cent and allocative inefficiency was 36.78 per cent in rice production in the study area. Average inefficiency decreased with increase in farm size indicating that big farms are more efficient than small farms in rice production.

A.R. Reddy is Scientist, ICAR Research Complex for Eastern Region, WALMI complex, Phulwarisharif Patna-801 505. C. Sen is Reader, Dept. of Agricultural Economics, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. R.R. Mishra is Asst. Professor, Dept. of Agrl. Economics, Rajendra Agricultural University, Pusa, Bihar.

India is facing challenges to feed its growing population. It was estimated that 260 million tonnes of food grains are to be produced annually by the year 2030 to meet food requirements. Therefore, means and ways to increase agricultural production to match the growing population are to be developed. There are two options for increasing agricultural production: bringing more area under cultivation and, or, increasing per hectare production per unit of time. Land being a scarce resource, further expansion in acreage is possible to a limited extent only. Productivity can be increased by adoption of improved technologies and management practices. Adaptation of new technology requires costly inputs in the form of improved seed, chemical fertilizers, plant protection chemicals and other inputs. Most of the Indian farmers being marginal and small with a very small resource base are not in a position to adopt these costly technologies. Adaptation of new technology also requires intensive input of management and information. Farmers in developing countries with low literacy rate, poor extension services and inadequate infrastructure, have great difficulty in understanding new technologies. Hence they are unable to exploit their full potential. If this is a once for all process farmers can adjust over time to this change. But this is a continuous process and farmers are, therefore, always in disequilibrium. In addition they have to cope with the disequilibria created by the changes in input and output prices. Available evidence suggests that farmers in developing countries fail to exploit the full potential of technology and, or, make allocative errors (Taylor and Shonkwiler, 1986, Ali and Flinn, 1989, Kalirajan and Shand, 1989, Bravo-Ureta and Evenson, 1994, Arindam Banik, 1994. Shanmugam et al., 1994. Sharma and Datta, 1997. Thomas and Sundaresan, 2000).

Inefficiency is the inability of the farmer to produce maximum possible output that can be produced by the resources available with him at the existing level of technology. Estimates on the extent of inefficiency will help to decide whether to improve efficiency or to develop

new technology to raise agricultural production.

Rice is one of the major food grain crops in India occupying 44.4 m. ha. with a production of 84.9 m.t. Hence it is very important to know whether there is any inefficiency in rice production or not. With this objective this study was conducted to quantify various inefficiencies in rice production in the Sone canal command area of Bihar.

Methodology

Technical inefficiency arises mainly due to the technical errors made in the production process while allocating resources. Economic inefficiency is the combined effect of these two inefficiencies. Technical inefficiency was derived by estimating stochastic frontier production while profit function was used to estimate economic inefficiency. Allocative inefficiency was obtained from these two.

Cobb-Douglas type of functions were used in this study which are given below.

Production function

$$\ln Q=\beta_0+\beta_1 \ln X_1+\beta_3 \ln X_2+\beta_3 \ln X_3+\beta_4 \ln X_4+\beta_5 \ln X_5 +\beta_6 \ln X_6+\beta_7 \ln X_7+\beta_8 \ln X_8+\beta_9 \ln X_9+(V_i-U_i)$$

Profit function

$$\ln P=\beta_0+\beta_1 \ln X_1+\beta_2 \ln X_2+\beta_3 \ln X_3+\beta_4 \ln X_4+\beta_5 \ln X_5+\beta_6 \ln X_6+\beta_7 \ln X_7+\beta_8 \ln X_8+\beta_9 \ln X_9+(V_i-U_i)$$

Where

Q = Yield of rice in kg

P = Variable Profit from rice production

$\beta_0 \ldots \beta_9$ = Parameters to be estimated

X_1 = Land in hectares

X_2 = Seed in kg

X_3 = Human labour in man days

X_4 = Bullock labour in bullock pair days

X_5 = Machine labour in hours

X_6 = Supplemental irrigation in rupees

X_7 = Fertilizers in kg

X_8 = Plant protection chemicals in rupees

X_9 = Manures in tonnes

V_i = random error having zero mean which is associated with random factors (e.g. measurement errors in production, weather etc.) which are not under the control of the farmer

U_i = one sided inefficiency component

This stochastic frontier was independently proposed by Aigner Lovell and Schmidt (1977) and Meeusen and Van den Broek (1977). The model is such that the possible production Y_i^* is bounded above by the stochastic quantity; hence the term stochastic frontier. The random errors, V_i, i = 1, 2, ..., N were assumed to be independent and identically distributed as N $(0, \sigma_v^2)$ random variable, independent of U_i s which were assumed to be non negative truncations of the N $(0,\sigma_u^2)$ distribution (i.e. half normal distribution). Given the assumptions of the above stochastic frontier model, inference about the parameters of the model can be estimated based on the maximum likelihood estimation because the standard regularity conditions hold. Aigner Lovell and Schmidt (1977) suggested that the maximum likelihood estimated of the parameters of the model can be obtained in terms of the parameterization $\sigma^2+\sigma_v^2\equiv\sigma_s^2$ and $\gamma = \sigma/\sigma_v$. Rather than using the non negative parameter g the parameterization of Battese and Corra (1977) who replaced σ_v^2 and σ_u^2 with $\sigma^2=\sigma_u^2+\sigma_v^2$ and $\gamma=\sigma_u^2 / \sigma_u^2+\sigma_v^2$ was utilized. The parameter γ must lie between 0 and 1. Inefficiency of an individual farm is given as below

$$\text{Technical inefficiency (TI)} = \frac{Q^*-Q}{Q^*}$$

$$\text{Economic inefficiency (EI)} = \frac{P^*-P}{P^*}$$

$$\text{Allocative inefficiency (AI)} = \frac{EI-TI}{1-TI}$$

A sample of 270 farms comprising 207 marginal (1 hectare), 31 small (1-2 hectare), 22 semi-medium (2-4 hectare) and 10 medium (4-10 hectare) farms were selected from different locations of the canal command through stratified random sampling method. Large farms were not included in the study as their percentage is very low and they were absent from the selected villages. Data pertaining to the agricultural year 2001-2002 were collected through personal interview method.

Results

Estimated coefficients of frontier production and profit functions are given in Table 1. Area, fertilizers, plant protection chemicals, machine labour and bullock labour showed significant positive effect on yield of rice indicating the scope for increasing production of rice by increasing the level of these inputs. Coefficient value of human labour was –0.2055, which was significant at 5 per cent level indicating that farmers were using excess human labour in rice production. Coefficients of seed, irrigation and manures were found to be non significant. Gamma value was found to be 0.8336 indicating the presence as well as dominance of inefficiency effect over random error.

Table 1: Coefficients of stochastic frontier production function for rice

Variable	Production function	Profit function
Intercept	16.1828 (0.44184)	8.7216 (0.7642)
Area	2.0521** (0.10646)	0.9358** (0.1669)
Seed	-0.35925 (0.21917)	0.1411 (0.1166)
Fertilizers	0.03095** (0.00926)	0.0249** (0.0056)
Plant protection chemicals	0.01516* (0.00621)	0.0109** (0.0041)
Irrigation charges	0.00624 (0.00685)	0.0022 (0.0039)
Human labour	-0.9185** (0.05702)	-0.2055* (0.1036)
Bullock labour	0.13072** (0.01583)	0.0572* (0.0222)
Machine labour	0.03653** (0.00816)	0.0173** (0.0063)
Manures	0.03601 (0.08069)	0.0566 (0.0635)
Σbi	1.02996	1.0405
Sigma squared	1.6236 (0.04546)	0.1974 (0.0305)
Gamma	0.89982 (0.00251)	0.8336 (0.07053)
Log likelihood function	-67.11	-55.5472

**Significant at 1 per cent level, *Significant at 5 per cent level
Note: Figures in the parentheses indicate standard errors

Estimated coefficients of the profit function revealed that independent variables such as area, fertilizers, bullock labour, machine labour (at 1 per cent level) and plant protection that profit from rice cultivation can be increased significantly by increasing the levels of these inputs. Human labour had a negative elasticity of –0.9185 which was significant at 1 per cent level indicating the over use of this input. Hence, profit can be increased considerably by decreasing the use of human labour.

Estimates of various inefficiencies in rice production are given in Table 2 and frequency distribution of sample farms based on inefficiency in Table 3.

Table 2: Estimates of inefficiency in rice production

Inefficiency	Marginal	Small	Semi medium	Medium	All
Economic Inefficiency					
Average	52.79	49.38	47.03	43.49	51.59
Minimum	11.38	11.07	11.84	10.67	10.67
Maximum	77.87	77.19	77.87	60.37	77.87
Technical Inefficiency					
Average	27.28	22.05	19.62	13.62	25.55
Minimum	7.38	7.07	7.84	6.67	6.67
Maximum	66.42	50.40	48.33	19.64	66.42
Allocative Inefficiency					
Average	36.92	36.97	35.83	35.19	36.78
Minimum	2.78	3.75	4.34	4.29	2.78
Maximum	64.24	68.17	67.17	52.91	68.17

Economic inefficiency

Economic inefficiency of sample farms ranged from 10.67 per cent to 77.87 per cent. The range was almost the same in all categories except in medium farms. The range of economic inefficiency in medium farms was 10.67 to 60.37 per cent, which was comparatively less. Average economic inefficiency of sample farms was found to be 51.59 per cent. It was 52.79 per cent in marginal farms, 49.38 per cent in small farms, 47.03 per cent in semi-medium farms and 43.49 per cent in medium farms. It is clear from the table that average economic inefficiency decreased with increase in farm size. It indicates that the farmers are not operating at the economically optimal point of production. Their resources were not optimally utilized in the production of rice. They are getting less profit from rice cultivation than what they have to get if they operate at the economically optimal level. Hence there is scope to increase the profit of the sample farms in rice production by 51.59 per cent without increasing the input levels.

Frequency distribution revealed that no farm was found to be functioning with less than 10 per cent economic inefficiency. Only 106 (39.26 per cent) farms out of 270 were functioning with less than 50 per cent economic inefficiency. Remaining 164 (60.74 per cent) farms were producing rice at more than 50 per cent economic inefficiency. Highest number of farms (61) was found in the 70-80 per cent class. This clearly

shows that farms are economically highly inefficient in rice production. As the farm size is very small in this area, farmers use higher doses of inputs, particularly human labour and seed, to get higher yields, making the farm more inefficient.

Table 3: Distribution of sample farms based on inefficiency in rice production

Inefficiency (%)	Economic inefficiency	Technical inefficiency	Allocative inefficiency
0-10	0 (0.00)	24 (8.89)	33 (12.27)
10-20	32 (11.85)	91 (33.70)	26 (9.67)
20-30	22 (8.15)	70 (25.93)	27 (10.04)
30-40	21 (7.78)	48 (17.78)	49 (18.22)
40-50	31 (11.48)	20 (7.41)	65 (24.15)
50-60	55 (20.37)	12 (4.44)	53 (19.70)
60-70	48 (17.78)	5 (1.85)	16 (5.95)
70	61 (22.59)	0 (0.00)	0 (0.00)
Total	270 (100.00)	270 (100.00)	270 (100.00)

Note: Figures in the parentheses indicate percentage to total.

Technical inefficiency

Technical inefficiency of sample farms ranged between 6.67 and 66.42 per cent with an average of 25.55 per cent. Range of technical inefficiency decreased with the increase in farm size. Technical inefficiency of marginal farms ranged between 7.38 and 66.42 per cent with an average of 27.28 per cent. Small farms recorded an average technical inefficiency of 22.05 per cent ranging from 7.07 to 50.40 per cent. Highest and lowest figures of technical inefficiency in the semi-medium group was 7.84 per cent and 48.33 per cent with an average of 19.62 per cent. The range of technical inefficiency of medium farms was very less (6.67 to 19.64 per cent) with an average of 13.62 per cent. Least inefficient farm was found in the medium group while most inefficient farm was found in the marginal group. This finding confirms that technical inefficiency decreases with the increase in farm size i.e., big farms are more efficient than small farms. This analysis shows that sample farmers were not producing what they have to produce with the resources available with them. With proper utilization and management of available resources they can increase the physical production of rice by 25.55 per cent. Scope to increase physical yield is more in marginal and small farms when compared with semi-medium and medium farms.

Frequency distribution based on technical inefficiency revealed that highest number of farms (91) falls in 10-20 per cent technical inefficiency class followed by 20-30 per cent class (70) and 30-40 per cent class (48). Thus, technical inefficiency of the bulk of the farms (209) ranges between 10 and 40 per cent. Only 24 farms recorded less than 10 per cent and 37 farms recorded more than 40 per cent technical inefficiency in rice production. This analysis clearly indicates that most of the farms are technically inefficient in rice production.

Allocative inefficiency

Allocative inefficiency of sample farms ranged from 2.78 to 68.17 per cent with an average of 36.78 per cent. Considerable difference was not observed in the allocative inefficiency of various size groups. Average allocative inefficiency varied marginally from 35.19 per cent in medium to 36.97 per cent in small farms. It is evident from the analysis that rice growers allocate their resources erroneously. If these allocative errors are rectified the production and profits from rice production can be increased considerably.

In case of allocative inefficiency maximum number of farms were found in 40-50 per cent inefficiency class (Table 3) followed by 50-60 per cent class and 30-40 per cent class. Thus, majority of the sample farms (61 per cent) have allocative inefficiency ranging between 30-60 per cent.

Results of this study clearly show the existence of higher level of inefficiencies in rice production in the Sone command area. Farmers are not able to utilize available technology to its maximum possible level. Moreover, they are making allocative errors leading to a higher level of inefficiency. Physical yields as well as profits can be considerably improved by the judicious use of available resources. Most of the farmers of the study area are not well educated and their resource base is also very weak. Infrastructure facilities available in this area are also underdeveloped. Hence, farmers were unable to achieve full benefits of technologies available with them. Hence, there is a need to strengthen these basic facilities so that inefficiency in rice production can be reduced in the study area.

Conclusions

Based on the results of the study it can be concluded that rice production in the Some canal command area of Bihar was carried out inefficiently. Farmers

of this area are not only making technical errors but also making allocative errors which are affecting the physical production as well as the profits adversely. If these error are alleviated, rice yields as well as profits can be considerably increased in the study area.

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The will to win is worthless if you do not have the will to prepare.

– Thane Yost

Book Reviews

Water Resources, Sustainable Livelihoods and Eco-System Services, *edited by Kanchan Chopra, C.H. Hanumantha Rao & Ramprasad Sengupta,* Concept Publishing Company, 2003, p. 450, Price: 575/-.

This book brings together some papers presented under schematic themes providing thereby an overview of the dimensions explored at both the plenary session and in the contributed papers. It covers wide range of issues at the micro-level, providing multiple perspectives of hydrology, economics, political economy and water related institutions. Water resources are examined both from the macro perspective and from the viewpoint of specific problem related or regional issues.

Quite a few contributors focus on emerging problem of urban and industrial pollution. Other papers analyze institutions for water management and aquatic eco-systems and the services that they provide for humans. Finally, papers in the last section point towards future challenges and provide directions for policy.

Amongst the papers focusing on macro situation, speculates related scientific and policy issues in the broader perspective of macro level as well as sectoral level water balances. The contributors from the multiple perspectives of hydrology, economics, political economy and water-related institutions viewed various aspects. The paper on the sustainable use of water in Indian agriculture illustrates the criticality of improving irrigation use efficiency in the efforts at bridging gap between demand and supply of water. The different methods for raising water use efficiency, among which technological changes to improve crop yields, institutional changes to motivate water savings on the part of different stakeholders and selective dependence on the rest of the world for food are important. The paper on hydrological perspective of the water balance reviews recent attempts at the forecasting water demand and supply for the agricultural, industry, power and household sectors and concludes on an appropriate water policy needs to be based on an understanding of the hydrological cycle and the eco-system services that water performs prior to and after being used for direct consumptive purposes by humans. The paper on institutional changes needed for appropriate demand management argues for multi-tier organizations of water users and a critical role for property rights which enables markets to function.

The second set of papers speculates specific problems or policy related issues related to water management either on national or regional perspective such as salinity of water in Saurashtra, efficient use of canal water in Punjab, water management in Haryana, declining groundwater levels in Rajasthan, technological interventions to improve availability as well as efficiency of water papers like potential for solar photo-voltaic pumping in Gujrat, local harvesting technology in the dry zone of Maharashtra and conservation of water in Pondicherry. These papers deals with other aspects as well like rainwater harvesting, industrial water pollution, valuation of water quality, environmental regulation of water quality etc.

Formal and informal institutions at different levels of management received due attention in the papers as well. There are two interesting papers studying the political economy of water and legal frameworks for solving conflict. Other paper examines the inter-state water disputes in India and the different framework within which solutions have been sought for them and the other paper studies and point out that water in the Middle East is not only a resource and technology question but also a political-strategic question. He warns that the potential exists for a war between Turkey, Syria and Iraq over the use of water in the Euphrates- Tigris river basin. Another paper points towards new possibilities of managing water using French approach rooted in "Patrimonial strategies". A patrimonial audit of water resources keeps in mind the varying claims of stakeholders and holds the water resources of the nation (in terms of both quantity and quality) in trust for the future.

Another issue goes beyond the traditional use-oriented treatment of water and extends to an analysis of the contribution of water bodies such as lakes and wetlands to human well-being considers the eco system services of water bodies. A paper on aquatic eco-system describes services such as treatment of human wastes, flood control and water recharge which rivers, floodplains and wetlands rendering for humans. Diversion of water flow from these bodies for so called economic uses has a cost that needs to be valued in terms of the long- run loss of these services. Another paper on study of floodplains in a twenty-five kilometer stretch of the Yamuna river in Delhi estimates the economic impact of bio-physical changes resulting from urbanization, embankment and encroachment.

The set of papers on eco system services of water, provides pointers to the trade-offs between developmental gains and gains from eco-system services that emerge when the ecological significance of fresh water eco-systems is recognized in making the choice among alternative land uses. Social decision processes need to be evolved for choosing between the provisioning (food and water), regulating (life-supporting) and enriching (cultural) functions of these eco-systems. Research needs to support such decision-making by providing clearer pictures of the elements in this trade-off, both in the long and short-run.

The last set of papers focused on providing directions for the future. Providing information on approach to water resource management, based on inter disciplinary perspective. Issues relating to attitudes towards the natural environment, appropriate institutional framework for decision-making and innovative technologies like wise critical directions that the future shall take.

The wide range of issues covered in the papers indicates that serious and interesting research initiatives in this emerging area of ecological economics are emerging. Increased recognition of the role of ecological services provided by eco-systems provides a challenge at the frontiers of research. The findings of research need to be integrated into policy-making processes using basic economic principles. In the era of globalization, new satellite –based technology and corporate forms of governance, any innovative institutions that link the local to the global need to be encouraged and strengthened and this is a challenge that presents itself in relation to an array of resources, among them water.

The papers in this volume put together these issues in a careful, well–researches manner for the discerning reader. I hope that these papers shall be of interest to a wider audience.

Rajesh Sund
Asstt. Director
National Productivity Council
New Delhi

The Dynamics of Technology Creation and Diffusion of Skills and Knowledge, *edited by Roddam Narashima, J. Srinivasan and S.K. Biswas,* Sage Publication, New Delhi, 2003, Hard Cover, p. 301, Price: 506/-.

In this edited volume the authors have emphasised that technology is a powerful engine whose creation and maintenance requires contribution from all, be they engineers, scientists, R&D people. Technology has become a major force in our daily life with huge resources being spent to develop newer technologies, products for global consumers. However, even as many embrace new technologies as a force for human good or national power, others dread it as socially disruptive.

This edited volume has ten essays. The issues which the contributors deal with are: How does the mighty engine work?, What are the roots of its power-social, economic, cultural or political?, How is technology created? and how it is diffused?

The first chapter by Ian Inkster deals with the history of technology during period 1700-2000. The history of technology is human history in all its diversity. Technology change is not the fundamental cause for other changes in society and polity but rather is a reflection of more general changes triggered presumably by historical factors. As different societies have been innovative in different ways at various time periods, the concept of barrier inhibiting technological growth assumes importance. The state also plays a key role in technology development and as a change agent. The writers point out many studies which describes the role of state such as Japan, China Russia, Holland. Another factor which has also contributed to technology transfer is the migration of people from one state to another Inkster concludes that on the whole, there is no accepted paradigm that guides the analysis of these important issues.

In chapter two, Hiroshi Sato discusses about technology transplantation or "invasion" which occurred twice, that lead to Japan's current technological prowess. First was the Chinese invasion through Korea during 5th to 8th centuries AD. At that time Korean talent came to Japan and brought Korean/Chinese tech-

nologies. These people settled down and came in the main stream of Japan. The second wave of transplanted technology began only in mid of 19th century as Japan realized that its traditional "closed door policy" of isolation was no longer tenable ad thus began a frantic programme of modernization. The new technologies were quickly absorbed and Japan signaled its strength around the turn of the 20th century with victory in the wars against China and Russia and world war first. The Japanese mastered many technologies such as building earthquake resistant buildings, bridges, ships, aircraft, electrical machines etc. After the second world war when Japanese were defeated, and Hiroshima and Nagsakai were bombed by Atomic bombs, Allied forces prohibited Japanese from making Aircrafts. After the second world war, Japanese made tremendous technological success in automobiles, electronics, shipbuilding, electrical machinery etc. Sato probes the reasons for Japanese success and attributes success to the curiosity of the people about new product, adoptability to changing circumstances, flexible attitude to religion and aptitude for hard work. Japanese believe in team work and be uniform and cooperative and avoid arguments. Sato states that Japanese were lucky to escape colonization unlike India.

Chapter three, by Narasimha deals with the history of technology. He cites that the Rocket technology was developed in 11th century in China and later by the Princely State of Mysore in the 18th Century. Tipu Sultan of Mysore during 18th century utilized rockets as a military weapon. The metallurgical skills of Indian craftmen who made rockets with iron casings was far superior to those available in Europe. Narasimha's analysis of science and technology in ancient India argues that the intellectual property rested in different communities, castes or families. Though the developments in science and technology/mathematics took place in India but unfortunately they did not characterize in scientific revelation as they rested within the families or communities. The development of materials used in rockets triggered further and new materials were developed of high temperature superalloys for gas turbines.

Chapter four and five of this volume discuss the history and the technology of new material development. Robert Cahn gives examples, how the dynamics of challenge and response have led to the creation of new materials. The history of strong fibres in carbon, glass, boron, polymers etc provides another fascinating story of challenge and response. He also observes significant role played by 'serendipity' in the development of new materials.

The extraordinary role that new materials have played in the emergence of new technologies however does not stop discovery of the new materials. It is followed by complex and series of activities that can be called product creation process.

In chapter five, Balasubramanian and Rama Rao describe this process in detail. According to them, it consists of a phase when information about needs and applications is collected and analysed, product ideas are conceived and evaluated, and designs are made. It is then that process technologies come into picture: basic technical knowhow for manufacturing is assembled, pilot production run is made, product is tested in the market place and teething troubles are sorted out before true commercial manufacturing starts. In this chapter, various processes of material manufacture have been discussed. Even high pressure, high temperature and vacuum technology and material deposition in chemical vapour form has been mentioned. The point that is driven home is that science and technology work together and that, whether the process occurs in the core of the earth or on the shop floor of the industry, principles remain the same, there is continuum. The very success of the enormous efforts in engineering has led to the new problems as well. The world has now become a consumer society and has become a profligate user of its resources.

In chapter six. Hugh Ford discusses these issues. He points out that as a result of progress made in material sciences and engineering, the quality of life improved enormously but the quantity of energy consumption has increased rapidly and has resulted in many problems globally.

There are questions concerning the environment and climatic changes. He cites many examples in his article stating that to make anything such as glass, train for passengers, aeroplane etc. requires enormous energy from raw material to final operation. Even resources like water which were earlier available in plenty is now becoming scarce due to wastage. Same is the case with fossil fuels which are not renewable and are slowly depleting. Ford concludes that as energy becomes a major concern, material usage should be rated according to the energy they consume during manufacture and processing. He points out the role of engineers who have been led in decision making more by financial and political forces than technological considerations.

In chapter seven, Ashok Ganguly gives a vivid account of how a great global industrial house like Unilever manages its R&D efforts. He points out that in today's world, finding "that seamless link between consumer needs, discovery and the market place – and doing so better and faster than the competitors' is what distinguishes the leader from the others. Market place

has now become competitive. Being first to market is crucial.

To achieve profit growth, R&D is essential although spending more on R&D does not guarantee bigger profits. Ganguly concludes with the thought that it is no longer going to be possible to succeed in business without continuous value addition through knowledge, as the business world is now characterised by a shifting balance of growth, markets and customer demands around the world.

In chapter eight Arnold Pacey distinguishes private technology from public technology as well private science from public science. Pacey considers the nature of private technology, driven variously by personal enthusiasms, a desire to promote something aesthetic, or to symbolize faith in technical progress.

Apart from this technical and aesthetic ideology, there have been several examples of engineering for humanitarian purpose. Indeed private enthusiasms have led to novel technologies, but they tend to become public when successful. Utopian projects do not always succeed but they may influence public perception as to what technology can do and thus priotise resource allocation.

In chapter nine, Hans Liepmann discusses the vast, complex engine of technology and how it cannot run without an array of engineers. He says engineers are often seen as assemblers of current technology into useful machines by applying well known recipes. He points out that education in engineering should address the industry needs. Life long learning is becoming essential. A link need to be established between industry and academia. He also talks about creative engineering to mundane engineering problems and how necessary it is to be able to make quick rough estimate of engineering parameters, even in a world increasingly dominated by competition.

In chapter ten, Kenneth Keniston, who has studied India's recent software and information technology boom in detail, seek to find out whether India's culture can survive the information age. India, as he says, is a "test case" as it has preserved a pluralist tradition in culture, language etc. for a long time. He feels, India, despite all the many conflicts of the past and present, live more comfortably with multiple culture identities than any other people on the earth. He feels India may indeed provide a model for the world.

The authors have attempted to show that technology is a mighty engine whose working has been shaped by political economic, social and cultural forces of the world, and the technology in turn has always been and is currently influencing the politics, economics, sociology and culture of the world. This book makes a very good reading especially for those engaged in understanding the impact of engineering and technology and how it shapes political, social, economic and cultural forces of the world.

S.K. Gupta
Management Consultant
D-4, Green Park Main
New Delhi-16.

State-level Reforms in India: Towards More Effective Government *by (Ed) Stephen Howes, Ashok K. Lahiri and Nicholas Stern*, Macmillan India, 2003, p. 325. Price: 450/-.

The objectives of economic reforms in India cannot be fully achieved unless the centre's efforts are supplemented by the state governments as states play a vital role in the key sectors of the economy viz. agriculture, health, education, infrastructure etc. Recognizing the importance of the state participation in the economic reforms, a three-day India States Forum was organized in New Delhi during November, 2000. The Forum was attended by participants representing all states/union territories (UTs) of India, besides a few international experts. A large number of papers on both Indian and International experiences on reforms were presented on the Forum. The book under review is a compilation of the select papers from the Forum.

The book consists of 21 different papers and a well articulated introduction by the editors. The book is divided into three parts, with each focusing on a particular aspect of the reforms. Part I has five papers on state level reforms in India – challenges and perspectives. In the second part international experiences on reforms are presented. The third and the final part of the book comprising nine papers discusses at length various reforms measures undertaken by some of the Indian states. The book covers a wide range of issues surrounding the fiscal and governance reforms at the state level e.g. e-governance, taxation of interstate trade, transparency, corruption, public relations perspectives of reforms etc. Like the issues covered, background of the authors is highly diverse. The book has the distinction of presenting in a single volume the experiences and views of the economists, bureaucrats, politicians, academia and journalists on the subject of economic reforms at the sub-national level.

The introductory chapter presents a broad overview of the papers presented in the book. The second chap-

ter is the inaugural address at the States' Forum by K.C. Pant, the then Deputy Chairman of the Planning Commission of India. It explains the importance of fiscal and governance reforms at the state level and the role played by the Planning Commission in supplementing the states' efforts in this regard. In the next chapter Digvijay Singh shares his experiences on reforms in the state of Madhya Pradesh. He commented that if economic reforms are to succeed it must introduce political decentralization as the first step. The paper by R.J. Chelliah addresses two fundamental questions on state level reforms in India viz. what reform measures need to be undertaken by the states to speed up poverty reduction and how to create conducive environment for initiating such reforms. In chapter five, N. Vittal describes the challenges on reducing corruption and increasing transparency in government functioning. The last chapter of part I, which is written by Rajiv Desai, is devoted to the issue of how to make reforms popular in the states.

Seven chapters of part II portray experiences on economic reforms in a host of countries from Asia and Asia-pacific region, Australia, United Kingdom etc. In chapter seven, Sanjay Pradhan presents results of an international survey on the impact of quality of government on investment and growth. He concludes that key priorities in governance reforms must include political and bureaucratic disciplines, greater transparency and accountability in financial management, aggressive performance monitoring, regular feedback from citizens etc. Malcolm Holmes in chapter 8 discusses, in details, the fundamentals of public expenditure management reform. The paper by Jon S.T. Quah evaluates India's anti-corruption strategy vis-à-vis other Asian nations and it also suggests measures for reform. Clay G. Wescott in chapter 10 discusses e-government applications in the countries from the Asia-pacific region. It discusses various stages, challenges and issues affecting adoption of e-governance in these countries. Chapter 11 by Mahesh C. Purohit presents case studies of the VAT structure in select federal countries such as Brazil, Canada and European Union. Deriving the lessons from these case studies the chapter also recommends a suitable VAT structure for India. The remaining two chapter (chapters 12 & 13) of part II narrate respectively the state-level fiscal reforms in Australia (by Percy Allan) and governance reforms in the United Kingdom (by Andrew Edwards).

Part III of the book is fully devoted to Indian experiences on state level reforms. The first four papers cover the issue on fiscal reforms, while the remaining five papers discuss experiences on e-governance. The chapter 14 by Fardoust & Lahiri presents major challenges that the states in India need to address in their road to reform, focusing mainly on the fiscal dimension of public service delivery. Y.V. Reddy reviews the efforts put by various Indian states towards fiscal reform (chapter 15). Experiences of fiscal reforms in Uttar Pradesh and Karnataka have respectively been discussed in Chapter 16 and 17. The last five chapters of the book focus on e-governance measures adopted by some of the Indian states. Cases of e-governance applications in Andhra Pradesh, Karnataka, Uttar Pradesh, Maharashtra etc. have been discussed at length along with the challenges faced in their implementation. The last chapter by Ravindra H. Dholakia discusses various reform measures undertaken by the Government of Gujarat in the post-1991 period in promoting private sector in the state.

As a whole the book is a very useful compilation of literature on economic reforms at the sub-national level and the first of its kind in the context of India. The book presents a diverse view on the state level reforms, especially fiscal and governance reforms and it tried to cover almost all key issues surrounding it. Economic reforms being an on-going process no single book can present a full account of all the reform measures undertaken till date. Yet, this volume fills the gap in the literature to a large extent. I am sure students, researchers, policy makers, analysts, businessmen, members of civil society and all those who keep interest in development issues at the state level would find this book very useful.

Utpal Chattopadhyay
Dy. Director (Economic Services)
National Productivity Council
New Delhi.

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News & Notes

World Competitiveness Landscape 2004

The IMD World Competitiveness Yearbook 2004 provides several customized rankings, whether global, by size, by wealth, by regions, etc. In the overall ranking, for example, the US ranks 1st, Singapore 2nd, Switzerland 14th, the Netherlands 15th, Germany 21st, the UK 22nd, Japan 23rd, China 24th, France 30th, Russia 50th, Italy 51st and Brazil 53rd. On the other hand, those whose position has improved the most are: Zhejiang 19th, Bavaria 20th, India 34th and Maharashtra 38th." Infact India has up 16 notches from 50th last year. This is India's best ranking in the last five years. Its ranking had slipped sharply from 41 in 2002 to 50th last year.

In 2004, India has taken off with a GDP growth of 8.1%. Much of the economic activity is taking place in specific areas such as Maharashtra, Mumbai, Bangalore, New Dehli, etc. India thrives on qualified engineers, scientists, low wages, and especially an English-speaking work force. As a consequence, the country is becoming a hot spot for the "offshoring" of administrative and back-office operations. But India is also developing its competitiveness in software operations, manufacturing, entertainment and financial ser vices. It is estimated that 2 million jobs in financial services will be relocated from industrialized nations to India up to 2008. **The main challenge for India will be to maintain a steady and predictable competitive strategy, avoiding the wide fluctuations of the past.** If it succeeds, it will emerge as one of the most attractive investment places on the competitiveness landscape.

During the latest recession, the 10th since World War II, weak enterprises disappeared, larger ones consolidated, and business confidence was shattered by recurring scandals. Today, investors are back but cautious, consumers are more positive but indebted, and governments struggle with long-term reforms such as pension and health care. Going through a recession is like going through a tunnel. After the darkness, a new landscape appears. In 2004, the competitiveness landscape has changed because the markets are more buoyant. But there is more to it. The structure of the World economy is now different.

The next new world will create the next paradigm in competitiveness that also leads to a structural change in productivity. According to the investment bank Goldman Sachs (Global Paper 99, 2003), China will be the largest economy in the world in 2050, with a GDP of $44'453 bn. It will be followed by the US with a GDP of $35'165 bn and India with a GDP of $27'803 bn. Three nations will be middlesize powers: Japan ($6'673 bn), Brazil ($6'064 bn) and Russia ($5'870 bn). Finally, Europe will constitute a cluster of smaller nations, where the largest ones such as Germany or Britain will have a GDP slightly above $3'500 bn. Altogether, Europe will account for a GDP of $25'000 bn. Asia is thus becoming a highly attractive place for world investment. Already, more than 60% of the foreign direct investments directed to developing nations are going to Asia. China alone attracts 32.5% of these investments. In 2003, for example, China exported more goods to the US than to Mexico, which is part of the North America Free Trade Agreement (NAFTA). As a comparison, Latin American nations received 34.5% of the direct investments going to the developing world and Africa only 5.8%.

The strong emergence of the larger Asian nations will generate a major shift in world competitiveness. It can be described in three steps: In the first stage, China, India, and most Asian nations are considered as providers of economic inputs to American, Japanese and European enterprises. As a result, China has become the manufacturing center of the global economy; India provides back-office operations, Thailand third-party assembling, etc. In a second stage, these nations build up some purchasing power and create a middle class, which develops and accumulates personal

IMD World Competitiveness Yearbook 2004													
Overall Rankings (2000-2004)													
Sl No	Country	2000	2001	2002	2003	2004			2000	2001	2002	2003	2004
1	Argentina	42	45	48	58	59	31	Lombardy				36	46
2	Australia	11	12	10	7	4	32	Luxembourg	3	2	2	2	9
3	Austria	18	14	15	14	13	33	Maharashtra				44	38
4	Bavaria				31	20	34	Malaysia	26	28	24	21	16
5	Belgium	19	18	19	18	25	35	Mexico	33	36	43	53	56
6	Brazil	38	40	37	52	53	36	Netherlands	4	6	4	13	15
7	Canada	8	9	7	6	3	37	New zealand	20	21	18	16	18
8	Catalonia				28	27	38	Norway	16	19	14	15	17
9	Chile	30	27	22	26	26	39	Philippines	35	39	40	49	52
10	China mainland	24	26	28	29	24	40	Poland	40	47	45	55	57
11	Colombia	45	44	42	45	41	41	Portugal	28	32	33	39	39
12	Czech republic	37	35	32	35	43	42	Rhone-alps				32	37
13	Denmark	12	15	6	5	7	43	Romania				51	54
14	Estonia		22	21	22	28	44	Russia	47	43	44	54	50
15	Finland	6	5	3	3	8	45	Sao paulo				43	47
16	France	22	25	25	23	30	46	Scotland					36
17	Germany	13	13	17	20	21	47	Singapore	2	3	8	4	2
18	Greece	34	31	36	42	44	48	Slovak republic		41	38	46	40
19	Hong kong	9	4	13	10	6	49	Slovenia	36	38	35	40	45
20	Hungary	27	30	30	34	42	50	South africa	39	37	39	47	49
21	Iceland	10	10	11	8	5	51	Spain	25	24	23	27	31
22	Ile-de-france				24	32	52	Sweden	14	11	12	12	11
23	**India**	41	42	41	50	34	53	Switzerland	7	8	5	9	14
24	Indonesia	43	46	47	57	58	54	Taiwan	17	16	20	17	12
25	Ireland	5	7	9	11	10	55	Thailand	31	34	31	30	29
26	Israel	23	20	26	33	33	56	Turkey	44	48	49	56	55
27	Italy	32	33	34	41	51	57	United kingdom	15	17	16	19	22
28	Japan	21	23	27	25	23	58	Usa	1	1	1	1	1
29	Jordan				48	48	59	Venezuela	46	49	46	59	60
30	Korea	29	29	29	37	35	60	Zhejiang				38	19

Source: IMD 2004, NPC serves as partner Institute from India for the Competitiveness Yearbook.

wealth. As a consequence, they become market providers. China is the fastest growing market in the world for mobile phones, but also for cars, steel, etc. India is keen on discovering more consumption goods, just as Malaysia and Singapore have done in the past. In a third stage, Asia will move to become a world competitor in its own right. Asia is creating homebred global companies and will start to export local brands. The same pattern was followed by Japan after the war. It has quickly emerged from a nation manufacturing cheap production goods (often ridiculed by foreign nations) to one developing world-class brands and moving up the added value ladder. Therefore, one can expect that larger Asian nations will emerge as strong players in world competitiveness. Japanese top brands such as Sony, Toyota, Nissan or Hitachi are now known all over the world. Chinese brands, for example, are less reputable, but they will follow the same pattern: Konka, Huawei, Haier, Huayi, Skyworth, Midea are names that will soon become more familiar to the rest of the world. TCL, another leading Chinese brand, has just bought the television division of the French company Thomson and has already become one of the leading manufacturers and vendors of TV sets in the world.

Economic cycles should not obscure the most fundamental trends that are emerging in the world competitiveness landscape of 2004: Asia, and soon Russia and Central Europe, emerge as world competitors in their own right. They will brutally assail the competitiveness of the US and Europe, as Japan did over the past decades. For governments, there are deficits and deficits: some are cyclical, but many are now structural. They are the result of a wealthy, ageing society that consumes more than it produces. Europe will suffer and may fail to reform itself. World manufacturing explodes but manufacturing jobs implode. The productivity boom spreads via globalization into low cost areas. The next paradigm shift will affect the service industry. There is light at the end of the tunnel of recession. For some countries, this will mean unprecedented opportunities for success and prosperity, for others, the competitiveness landscape that unfolds may be too bright and blinding. The World Competitiveness Yearbook provides a glimpse of this new world. Some nations will adapt, some will muddle through, and some may be left behind. President Ronald Reagan summarized the situation quite well:

"There are those who make it happen, those who let it happen, and those who wonder what happened!"

Compiled by
Rajesh Sund
Assistannt Director (ES)
□

Pleasure in the job puts perfection in the work.

– Aristotle

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