PERSPECTIVES

presents emerging issues and ideas that call for action or rethinking by managers, administrators, and policy makers in organizations

Technology and Economic Growth: Quo Vadis, India?

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Executive Summary

While the movement for independence of India was being led by the political leaders and social reformers, there was emerging another community of leaders—scientists and technologists—whose contributions remained unnoticed and unrecognized for a long time. If the politicians laid the foundation for a democratic India, the scientists created a fertile environment for building a science-based society in the country. Amongst them were those visionaries who also comprehended the links between science, technology, and economic growth.

Drawing from the economic growth theories, this paper demonstrates how technological innovations worked as the engine propelling economic growth of cities and nations and addresses four specific questions :

- What is the basis for economic growth?
- How can this growth be improved and sustained?
- How can it be spread across the country?
- What will be the reaction of the developed countries to such challenges?

The author closely studies the case of information and communication technology-based growth of Bangalore and explores the possibilities of its extension to other cities. He attributes Bangalore's economic growth to social, cultural, and infrastructural factors unique to the city. A comparison of Bangalore's growth with a few other locations suggests that it is not possible to blindly replicate the success story of Bangalore in other regions of the country. What has worked for Bangalore may not be relevant for those regions. What is required is a strong base and, for that, the country should start building the infrastructure and educating the labour. For diffusion of growth, the author stresses upon the need for identifying local strengths, encouraging local innovation, intensifying educational programmes, and respecting the sociological systems and local culture.

Overall, the author draws the following lessons for India:

- Population—trained and educated—is an asset.
- Labour will be an asset only if there is adequate infrastructure for the use of the genetic pool.
- Energy, communications, and transport systems should be ubiquitous, reliable, and affordable.
- Setting up of profit-seeking R&D centres and R&T institutions should be encouraged.
- Market size and competition should be increased.
- Transaction costs will have to be minimized.
- Ideas, knowledge, and skills should be allowed to come from anywhere.

This improved understanding of the forces driving social development and economic growth offers enticing options for India to pursue.

KEY WORDS

Economic Growth

Technology

Bangalore Phenomenon

Education Programmes

Outsourcing

Note: This paper is based on the Vikram Sarabhai Memorial Lecture delivered by the author on 29th November, 2004 at Indian Institute of Management, Ahmedabad.

India had more than its share of political leaders and social reformers during the days of its independence movement. We still do not have the necessary historical distance to understand the environment that produced such leaders. Perhaps, fighting for freedom was such a powerful emotive cause that it fostered an environment conducive for the growth of freedom fighters. During the very same decades, there was also another group of leaders emerging that was not so well recognized by the rulers and ruled at that time: scientists and technologists. Unlike politicians who were concerned with the immediate job in hand, the scientists were building the base for a modern post-independent India. They were conscious that although modern science and technology was Western in origin, that did not stop them from embracing it. There were not many pursuing science in India then, but their contributions were outstanding. Srinivasa Ramanujan, SN Bose, CV Raman, JC Bose, and S Chandrashekar had all made lasting and seminal contributions in their chosen fields. Occasionally, they also spoke of the freedom that science gave them even while living in an occupied land. If the politicians laid the foundation for a democratic India, the scientists created a fertile environment for building a science-based society in the nation.

There was also another group of scientists who, in addition to excelling in science, also understood the relationships existing between science, technology, human development, and economic growth. They argued that the prosperity of Western nations could be traced to the successes of those countries in developing and applying technologies for economic growth. The Industrial Revolution of the late 18th and 19th centuries that replaced muscle power by mechanical and electric power provided the engine for economic growth and improvement in the quality of life in Europe and the United States. For India to similarly benefit, this group of scientists opted for promising new technologies that were just then unfolding. Such technologies, they believed, would be more efficient to offset the years of neglect with minimal growth, and also provide a level playing field among nations. Vikram Sarabhai, Homi Bhabha, and SS Bhatnagar belong to this group of visionaries. Dr Sarabhai understood the relevance of peaceful applications of space even well before the Western nations and set to develop the necessary elements of space technologies in the country. He envisioned a multi-pronged approach that involved investing in the training of Indian technologists and also acquiring a few key technologies from abroad. Instead of building a few large vertically integrated research and manufacturing centres, he focused on nurturing relationships with industries and laboratories already existing in the country. He understood the importance of working with other nations that were technologically more advanced and built non-confrontational relationships with foreign laboratories. He was the earliest to suggest the deployment of geo-stationary satellites for education, information, and entertainment. His vision was translated into many engineering projects resulting in the injection of a galaxy of INSAT satellites in space. These satellites have enabled to integrate the country as never before in its history. Communications, entertainment, and educational programmes from the satellites beam across the entire nation with no region left behind. Arthur C Clarke's science fiction of geo-stationary orbits has been realized in real life.

TECHNOLOGY AND ECONOMIC GROWTH

Vikram Sarabhai and probably Homi Bhabha, because of their proximity to the business world, knew the importance of technology for economic growth better than many politicians in power then. Their identification of technology as the engine propelling economic growth was in line with some of the theories emerging at that time. Robert Solow, a well-known Economist, showed that it would not be possible to account for all the economic output based solely on inputs from capital and labour. A fraction of the output that could not be accounted on this basis was called residual and he speculated that as coming from technological innovations. He was unable to uniquely identify the source for this output and suggested that this could be from outside the economic system (exogenous). This was followed by a paper by Kenneth Arrow who suggested that improvement in the quality of labour with time, the so-called 'learning by doing' could be responsible for the residual. In a series of seminal papers that appeared in the 1990s, Paul Romer showed how technology is not a given from outside the formal economic system (exogenous) but generated within the system. This endogenous growth is driven by people contributing to R&D, technology development, and skilled labour, and the economic and social environment that encourages competition and innovations. The new growth theories of Romer and others emphasize the importance of an educated, trained,

and skilled workforce in providing the industrial base. In addition, the other prerequisites for economic growth include physical infrastructure and a competitive business environment. In the same context, technology absorption from outside also becomes attractive as a means to augment the scarce local scientific and technological human resources.

ECONOMIC GROWTH OF NATIONS AND CITIES

How do technological innovations work in the economic growth of cities and nations? This is the theme we shall examine in this paper focusing on how the lessons we learn from a city's tryst with technological innovations may be useful in spreading growth across the country.

Exhibit 1 summarizes the economic growth of two countries in the past few decades. It also shows that countries like Korea (India, to a smaller extent) could catch up with the well-entrenched Western countries capitalizing on technological innovations. If Indian income in the 1960s were linearly extrapolated to 2003, the growth would have been a mere 30 per cent. Instead, it has tripled. Some countries in Africa have not as yet experienced this growth phenomenon. In a few countries, the economy due to war, famine, and AIDS, has actually shrunk.

The gross national product (GNP) of a country does not describe the various inequalities existing within the country. Some areas may be boom locations while others may be depressed—all at the same time. It is also difficult to directly relate the quality of life index to GNP. Kerala provides a unique example of how even with modest GNP, it has an enviable Human Development Index, better than a few developed countries. Is it possible to emulate economic and social successes to other locations? What makes a town boom, especially when it is not sustained by commodities like oil or a mineral for its growth? If the driver is technological innovations, then it should be theoretically possible to transplant such successes to other locations as technology is non-rival and non-excludable. For instance, the use of technology at one location does not prevent its applications in other places.

Exhibit 1: The Growth Miracle

- Long-term sustained growth unknown before 1800.
- Between 19th and 21st century, per capita income increased over twenty-fold, and life expectancy more than doubled.
- Many countries experienced the growth phenomenon: Korea achieved in 30 years (1960-90) what took UK the entire 19th century!
- Indian income tripled between 1980 and 2002.

BANGALORE: A CASE STUDY

Bangalore with its impressive growth of Information and Communications Technology (ICT) provides an interesting case study. Exhibit 2 summarizes some of the features of the Bangalore phenomenon.

Among the three billion dollar ICT companies, one is actually home-grown, the second moved into the city a few years back, and the third, Tata Consultancy Services, has its major work centre in that city. In addition to these three major software companies, the city sustains a large number of medium and small ICT companies and a number of multinationals such as Microsoft, IBM, Oracle, and Honeywell. The growth rate is so large and spectacular that the city's infrastructure is overstretched. The rents are high, good building space is hard to come by, and there is also a growing scarcity of qualified professionals.

This growth has also generated an increasing interest in setting up R&D centres in the city. Many global corporations such as GE, GM, and Honeywell have established major R&D centres in Bangalore. Texas Instruments was the first to initiate this move and the latest is Microsoft which is locating one of its three R&D centres outside the US in Bangalore.

There are four key issues that must be addressed before it is possible to analyse the feasibility of transplanting the Bangalore phenomenon to other areas and cities: (i) the basis for economic growth, (ii) sustainability, (iii) amenability for emulation, and (iv) reaction of developed countries to such challenges, the so-called outsourcing.

Bangalore's economic growth can be traced to social, cultural, and infrastructural factors that are unique to that city. The city has a favourable climate; it is multicultural with many languages being spoken. English is spoken or understood by a large fraction of the educated population. Traditionally, there has been a strong presence of military—with members from all parts of India—in the city from the British days when many British

Exhibit 2: The Bangalore Phenomenon

- Three major billion dollar Indian ICT corporations
- More than 200 medium-and small-sized ICT companies
- Spectacular annual economic growth of the city
- Scarcity of qualified human resources

officers (including Winston Churchill) were stationed in the cantonment areas. There is, thus, a tradition of accepting different cultures and learning to work with them. The state and local administrations are less authoritarian and much less intrusive. Bangalore has a long and rich tradition of pursuing science, engineering, and technology. Its hydroelectric power station at Sivasamudram is a century old unit. It has a steel plant at Bhadravathi, the only steel plant to have been set up in a princely state. The Mysore Engineers Association is more than a century old. The Indian Institute of Science, the country's outstanding R&D University was set up early in the 20th century by the great Indian industrialist and philanthropist, Jamshedji Tata. Along with this, a few good educational institutions were also established in the city. For many years, in the 1940s and early 1950s, Bangalore was one of the very few Indian cities that had more than a few engineering colleges.

In India, Bangalore has perhaps the highest density of R&D laboratories and advanced technology industries. The Defence Research and Development Organization (DRDO) alone has a number of laboratories working in areas as advanced as artificial intelligence and phased array radars. The conglomeration of professionals working in industries and laboratories provided the necessary impetus for the people in the region to opt for engineering and science education. The commitment to education is fairly high in the educated families in the Indian society and this, in turn, provided the drive for 'learning by seeing others!' In Bangalore households, high technology systems and products are not seen as esoteric, but as familiar ones, and some are even manufactured locally.

Computer software was, thus, not unknown in Bangalore. When there were new opportunities in this area, often initially sought by local R&D projects, a number of companies came forward to meet those demands. A few large corporations also moved into Bangalore and that brought more orders from the civilian world as well. As the software industry was relatively new, the local software industry did not encounter any serious difficulties in competing for orders. The state and central governments also came along to provide support through fiscal incentives and building a few critical infrastructure needs in communications. The transaction costs involved in manufacturing ICT products and services were also minimal and did not require either commodities that were in short supply or special licenses, permits or quotas. These features minimized avenues for corruption and other undesirable practices that are endemic to manufacturing industries in the country.

CHALLENGES TO GROWTH

Can Bangalore continue to grow expanding its software market and are there problems it must address to retain this leadership? Software market is global and it will continue its growth as the technology finds additional uses and applications. Many believe, taking the analogy of electricity, that this growth would continue for decades with the continual development and deployment of new applications. India's share in the global software market is presently less than five per cent and, thus, there is a large potential for growth. But, some software services and applications are getting commoditized and, in the coming years, there could be competitors for this part of the work, especially from other developing countries such as China. Bangalore must, therefore, move up the value chain in software and develop new applications. Innovation becomes mandatory as does anticipating the needs and requirements of a global marketspace.

There are also other concerns. The physical infrastructure of Bangalore that was once envisaged as a mid-sized cantonment town by the British is over-stretched to such an extent that the city's day-to-day problems have started discouraging companies from moving in. This is typical of an overheated economy but a balance between demand and supply of basic infrastructure is reached in a short time. This does not seem to be happening. The rents remain high, the roads are heavily congested, and there are frequent blackouts and brown-outs. All these prevent a fuller utilization of human resources. There is also a need for revamping the educational system to ensure that more colleges and universities strive to produce better educated and trained graduates. There are concerns that the pursuit of quantity has adversely affected the quality of offered education. The industrial training institutes to train skilled workers are also scarce in the city and its adjoining regions.

There are concerns that the so-called outsourcing of white-collared employment to India would result in the developed nations erecting protectionist barriers that would make trading difficult. Because of the existence of the World Trade Organization (WTO) and the agreements it has enforced among nations, such concerns are overblown. However, there could be political pressures exerted to substitute free trade by their versions of fair trade. But, soon, the opponents of free trade would

realize that the software market is large enough to accommodate global participation.

ON SPREADING GROWTH

Our studies on the growth of Bangalore and a comparison of this growth with a few other locations suggest that it is not possible to blindly replicate this success story in other regions of the country. More likely, what has worked for Bangalore will not be relevant for other cities or regions. For instance, Ranchi has a favourable climate—some would say better than Bangalore—with beautiful hills and valleys and an excellent engineering educational institution nearby. It has also received the munificence from the central government with the establishment of engineering industries and a centre for iron and steel research. But, there is no industrial or economic growth as compared to Bangalore. However, Pune and Chennai are excelling in the manufacture of engineering goods such as automobile components. To be fair, we have not completed any detailed studies on Ranchi and qualitative analysis can go only this far. Even with this disclaimer, we suggest that there are lessons to learn. Exhibit 3 describes some of the imperatives suggested by Prof Stiglitz in a recent talk at Bangalore which may be appropriate for our discussion.

With all industries becoming more and more knowledge-intensive, there should be a major emphasis on education at all levels. Illiteracy has become too large a burden to be carried by any society especially for a country like India that is aspiring to provide for the basic needs of all its citizens and has a long way to go in overcoming its centuries of economic and social stagnation. While deregulation and privatization are being touted as the only way to improve competitiveness, it is important to remember that the state has a major role to play in the life of its citizens and cannot abdicate all its responsibilities to private interests. The recent power crisis experienced by Californians arising out of electricity deregulation and the not-so-fair trade war fought among telecommunications service providers in the country underlines the importance of state control especially with regard to providing basic amenities such as healthcare, education, transportation, and communications.

Social interventions by the states have long-lasting, beneficial, and occasionally unexpected but welcome consequences. For instance, the Mid-day Meal Programme for the school students of Tamil Nadu led to an impressive increase of girl students in schools and, what is more, reduced the overall birth-rate! The widespread availability of bottled cooking gas in Himachal Pradesh and Sikkim has increased attendance at schools as children did not have to spend time looking for and collecting fuel-wood. Such true and easily verifiable stories suggest that the states should, in addition to providing for basic infrastructure and amenities to its people, look for social interventions that are imaginative and supportive of the broad objectives of human development.

Exhibit 3: Thrust Areas for Growth

- Technology
- Education
- Role of the state
- Jobs, employment
- Equality
- Exports

AND, A NOTE, IN CONCLUSION

Industrial revolutions fuelled by radical technological innovations provide unique opportunities to societies to improve the quality of life of their people and make them economically well-off. The Industrial Revolution of the 18th and 19th centuries transformed many poor rural economies of Europe into prosperous industrial societies. The recent spectacular growth of a number of technology areas and our improved understanding of the forces that drive social development and economic growth offers enticing options for India to pursue. And this is the route that Vikram Sarabhai pioneered in the area of space exploration and contributed to the integration of our nation. That we take our satellites so much for granted is the greatest tribute we can pay to the technological development.

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