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Barriers to Innovation & the Creation of a Knowledge Society in India

by

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Abstract

In this paper, we identify the principal societal, systemic, organizational and governmental barriers to innovation and the creation of a knowledge society in India.

Societal barriers include an ambivalent attitude towards knowledge, a "knowing-doing gap", hesitation to specialize, a static view of technology, intolerance of failure, and a declining respect for diversity and dissent.

A lack of design and experimentation in engineering curricula, lack of cooperation between firms, lack of depth in different industries, absence of a culture of debate, and barriers to the founding and growth of high technology firms are systemic barriers.

Organizational barriers to innovation start from a lack of ambition and vision at the top, and include the perception of loss of control by owner-managers in issues related to technology development, inadequate investment in plant and machinery, the lack of the right people and skills, and hierarchical structures.

The government does not give enough flexibility to organizations under its control and emphasizes procedures over results. Long decision cycles, inappropriate choice of priority areas, and biases against start-ups in governmental support programmes for research and development are other governmental barriers to innovation.

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Introduction

Citing India's success in the software industry, the growth of the BPO industry, and our large number of college graduates, we pride ourselves on having the components of a modern knowledge society. How far is this representative of the truth? We have some of the trappings, but do we really have the values and the culture needed for a knowledge society? In what follows, I will argue that in spite of the growth of the industrial and services sectors during the last twenty years, there still remain major barriers to technological innovation in India, and more broadly to the creation of a genuine knowledge society itself.

What follows is based primarily on my own insights into these barriers and how they impede the process of knowledge creation, commercialization, and diffusion. My personal insights are supplemented by interviews and discussions with experts..

For some observers, competition is the principal and only driver of innovation. Neoclassical economists in particular believe that if you create conditions for competitive markets to function, innovation will follow. But this view is not restricted to economists. As one senior scientist with a long career in policy formulation and implementation told me, "innovation is done only under fear,"[2] implying that only the fear of being overtaken by other companies prompts firms to innovate. In another discussion, the editor of a leading financial newspaper shared this view. At the other extreme, Marxist scholars believe that competition will only serve the interests of the rich and powerful, typically the multinational corporations. One scholar expressed to me his skepticism regarding the transformation of the trading and opportunist mindset of the typical Indian business house into a productive industrial mindset, let alone an innovative mindset.[3] Another

commentator, Dinesh Abrol, writing about the prospects of the Indian pharmaceutical sector in the post TRIPs regime, is similarly pessimistic and sees the role of Indian corporations being restricted to certain niches allotted to them through a process of the international division of labour orchestrated by the Multinational Corporations. Though he does not rule out the possibility of Indian pharmaceutical companies innovating drugs, he does not see this happening without considerable support from the innovation system.[4]

The truth lies somewhere in between. While competition is an important motivator for innovation, this does not imply that innovative firms will automatically emerge in a competitive environment. The broader external context and the internal governance systems in firms will influence their motivation and ability to innovate. There are behavioural (related to widely prevalent values, attitudes, beliefs and behaviours), systemic, organizational, and government-related barriers to innovation. To enhance the innovative potential of the Indian economy we need to step back and view the innovation system as a whole, identify these barriers, and take purposive action to remove them. In the following sections, we seek to identify the barriers to innovation in the Indian economy. Our focus is on the organized sectors of the economy though we recognize that there are broader issues regarding poverty and illiteracy that will in the long run place a cap on the extent to which India can become a knowledge economy.

Behavioural (Societal) Barriers

Firms operate in a societal context and are run by people who are a part of the broad social milieu. How do our social values and beliefs affect innovation?

Some years ago, Ramar Pillai became, in a short span of time, a national hero. His claim to fame was a herbal fuel that could be produced at negligible cost, yet was claimed to have an energy content comparable to petroleum products. Members of parliament from his home state vociferously supported his claims, and accused various national agencies of conspiring against their compatriot by not rushing forward to assist his research and adopt his technology. It was weeks before a proper scientific test could be conducted and

this revealed that there was nothing revolutionary about his process. Less charitably, it looked as though his claimed wonder fuel was really a fabrication. The nation watched spellbound as this spectacle made national headlines and even after the fabrication was proven many MPs believed that there was some conspiracy afoot.[5] So much for belief in the scientific method in India - who would believe that the Indian constitution lists "developing a scientific temper" as one of our fundamental duties?

Cut to 2002. Manindra Agrawal is a young professor at the Indian Institute of Technology at Kanpur. Unlike many other products of his alma mater, Manindra chose to stay on at IIT Kanpur after his bachelor's degree to obtain a masters degree and a Ph.D. This did not stop him from getting together a group of students and focusing on one of the most difficult problems in discrete mathematics that remained unsolved for more than a hundred years. In 2002, Manindra and two of his students announced that they had devised a technique for a computer to tell whether a number is a prime or not. Within days this was confirmed by his peers around the world, making him the subject of a story in the *New York Times*.[6] His achievement merited a brief mention in the newspapers, but he has never been lionized by our press or society unlike sportsmen with less significant achievements. Who is recognized in our country? More "the smart ass who beats the system" than the one who struggles to solve difficult problems![7]

These two instances raise legitimate questions about whether we actually respect knowledge in Indian society.[8] And these questions can be raised without even talking about some of the more bizarre incidents that have taken place such as the mass hysteria accompanying the supposed drinking of milk by idols all over the country[9] or the reports of medieval "chastity tests" being conducted on women in Madhya Pradesh.[10]

In fact, our attitude towards knowledge is at best ambivalent and in many cases downright hostile. When a theory is proposed, it is too "theoretical", too "academic". As a teacher of an applied discipline such as Management, I am confronted by this issue all the time. People want a quick fix, a framework that can directly address or solve a problem, not a more general and perhaps abstract idea that can give interesting insights

but not be applied without careful thought and application. This problem extends to even more practical applications. Someone I know was developing a software product that could be used as a decision support system for one of our armed forces. It made quick calculations of some parameters that would enable a decision-maker to exercise his judgement and take a quick, well-informed decision. But the user wanted an automated solution that would tell the user what exactly to do. On the other hand, when examples are given or cases cited, we say "can you generalise?". If you thought people were happier with examples from practice, think again. Then people put on their analytical caps and ask for generalization, not realising that the process of induction is an important means of generating theories.

We suffer from a "Knowing-doing gap".[11] In societal and organizational settings, there are the highly intellectual thinkers who do not act, and the doers who disdain thinking! This is rampant across the economy, though I am not sure why. Perhaps it is due to the way we teach with theory and practice often in separate compartments. Or because much learning is by rote, we fail to "own" our knowledge. Year after year we teach our students project management with its wide range of tools and techniques. But when an opportunity to apply it comes along – like the collaborative and complex task of producing a placement brochure with details of all the students within a challenging timeframe – project management is conspicuous by its absence. Though we recognize that systematic market research can give us useful insights into consumer preferences and behaviour and thereby lower the risk of new product launches, stories are legion in the corporate world of instances where the top management (particularly in family-managed businesses) ignored market research and preferred to go ahead based on hunch or intuition, often with disastrous consequences. We have an excessive admiration for action, even if it flies in the face of carefully conceived wisdom: Perhaps this is a part of the techno-managerial culture in which we live. The hero is the swashbuckling Sangliana or Jagmohan, not the careful administrator behind the scenes who takes action after considered thought and public consultation.

An important corollary of the importance of knowledge is the importance of specialisation. In his book *The Competitive Advantage of Nations*, Michael Porter argues that competitive nations are those whose national environments promote the development of specialised skills and assets. Yet, we hesitate to specialise or acknowledge the importance of specialised skills & knowledge. Individuals have a predilection for keeping their options open. We still cling to a generalist culture. The "backbone" of our administrative system, the Indian Administrative Service (IAS) still believes that it can do everything well and the government does not have specialists in enough positions. If anything, over time, the number of specialists in senior positions in government has declined. A related generalist trend is in the field of management where MBAs think they can manage everything. They are gradually becoming today's generalist elite, replacing the IAS!

We take a static and passive view of technology and its integration in products and services – we tend to focus on manufacturing rather than on innovation. Many in India still retain the Marxist view that the key to development and productivity is owning the means of production. If you have access to the "latest" manufacturing technology, it should be possible to be globally competitive. This flies in the face of abundant evidence that there is more to technology and productivity than just the manufacturing plant and equipment. The story of the improvement of technological capabilities by the East Asian countries is replete with stories of how they took technologies from their partners (typically western MNCs), but then adapted and improved them to improve shop floor efficiency.[12] They subsequently innovated on the product side as well, and made whatever changes were necessary in the manufacturing process to suit their new products.

The history of innovation and knowledge creation makes it clear that many outstanding products and technologies emerged from failures. Du Pont's Nylon and 3M's Post-it notes are two excellent examples.[13] From trying many different kinds of experiments and learning from their outcomes, come many inventions and innovations.[14] There is nothing to be ashamed of trying and failing as long as there is some learning from the failure. Yet, we refuse to acknowledge the role of failure in knowledge creation and put too much

emphasis on avoiding "wastage." The fear of wastage is perhaps an outcome of scarcity of resources and underdevelopment, but unless we are willing to live with "intelligent failure" we can not create new things. Similarly, we underestimate the value of learning by doing - "let's not reinvent the wheel" is a familiar refrain. This is closely related to the points made above. To get into a new area or to improve and existing technology, it is sometimes important to be able to understand the know-how and know-why of the product or technology first. This might often mean "reinventing the wheel." The intention here is not to reinvent the wheel but to be able to understand enough of the phenomenon to be able to improve upon it.

We have problems in acknowledging that the past may not be exactly what we want it to be. Dissatisfied with what we are able to achieve today, we often look to the past for lost glory. In the process, we would like to attribute all the best things to the Vedic ages even if the claims made are difficult to sustain. Little is to be gained by repeating the achievements of India in ancient times – if at all, such repetition only shows that we have been unable to build on what we achieved then. We ignore the study of history and social sciences at our own peril – "those who cannot remember the past are condemned to repeat it."[15] The rapid decline in the study of the humanities and social sciences[16] should be of great concern to anyone who believes that India is or aspires to be a knowledge society. No modern society can live by technology and management alone – understanding culture, society, politics, history to name just a few critical disciplines is imperative to administer effectively a multi-cultural, multi-religious and multi-linguistic country such as India. We state with great pride that all our best students go into Engineering and Medicine, but surely there will be a price to pay for this in the years to come.

When we don't do well, we blame the rules of the game – whether it is in international trade or management research, unlike China which takes the rules as given and finds pragmatic ways of advancement. We take part in a number of international events, from business to field hockey, fail to do well, and then blame the referee or umpire or the rules of the game (though the latter were known to us from the start). Blaming others and

externalising failure may be a good defence mechanism but it's not conducive to knowledge and corrective action. In a related vein, we don't respect intellectual property, and perhaps take even a perverse pride in violating IPRs! Though there has been some slow change on this, the fact is that we still lack adequate respect for intellectual property rights. There are admittedly many flaws in the global system of IPRs and the system is loaded in favour of the developed world, but having decided to be a part of the system we had better learn to play the game. The lack of respect for IPRs is sometimes attributed to our being a collective culture. While it is ridiculous to see companies from other countries taking patents on natural products that have existed in India for centuries, we need to fight these wrongly granted patents rather than trash the patent system as a whole.

We allow books and movies to be banned if they hurt sentiments. This is a contentious issue and many people would say that maintaining peace and law and order should retain priority over freedom of speech and expression. While I would concede that there might be some extreme cases in which the right thing to do would be to ban works of art or literature, this power needs to be used with caution. The moment the government shows that it is willing to consider such requests, it opens the floodgates for pressure from some group or another. The governments try very little to make groups more open to consider alternate points of view. Dissent and criticism are vital for the creation of knowledge and clamping down on dissent and criticism at the slightest provocation does not enhance the process of knowledge creation. In his book *The Rise of the Creative Class*, Richard Florida has shown how the places that attract the most creative people are those that tolerate and even celebrate the greatest degree of social and cultural diversity. An important positive feature of the Nehruvian Indian State was its tolerance of diversity on multiple dimensions – religion, caste, language to name just a few. Recent attempts to take a more narrow view go against the creation of knowledge.

Systemic Barriers to Innovation

Systemic and organizational barriers reflect and reinforce these societal barriers to innovation.

Students go into engineering not because they have a keen interest or an aptitude for the subject, but because it is seen as the passport to a good job. After completing engineering, the best students irrespective of their specialization tend to gravitate towards the software industry because of the attractive jobs and lifestyles it offers. Our education system remains isolated from industrial innovation and problem-solving. Thousands of engineering students do projects each year, but these are largely unrelated to the engineering problems of industry or society.[17] Existing curricula and the way they are taught under-emphasise design and experimentation. Statistical skills are not imparted with adequate depth.

Few Indian engineering institutions offer courses that give students practical design skills, i.e., which integrate design theory and practice and that require students to create working prototypes. Workshop facilities are poor and even where such facilities exist (as in the IITs), the deterioration of administrative systems has fuelled the decline of workshop facilities. As a result, some institutes have given up the requirement of a design project in the final year, or relaxed the earlier requirement that the product designed "should work." Simulation and other computer-based projects have displaced the more practical design-based projects.

In the area of industrial design there is a slightly different problem – while the Industrial Design Centre (IDC) at IIT Mumbai and the National Institute of Design (NID) at Ahmedabad produce qualified industrial and product designers, companies have experienced difficulties in making best use of them. A related problem has been finding a common language between designers and the manufacturing and marketing departments At least partly as a result of these problems, many industrial designers have set up independent design boutiques but have found that product design projects are few and far between.

Only a small number of Indian companies have employees who combine the technical and managerial skills needed to take on the role of project managers for new product

development projects. With authority in Indian companies going more with seniority in the hierarchy rather than skills and capabilities, it is very difficult to find employees who can take on the role of "heavyweight" project managers even if the companies want to set up heavyweight project teams.[18] Further, engineers who have come up from the shop floor and managers in functions like marketing tend to speak a different language altogether.

Pankaj Chandra, a professor of operations management and a keen student of Indian manufacturing practices, sees other systemic barriers to innovation.[19] Several dimensions of the mindset of the Indian manufacturing system worry him. Indian firms get bogged down and do not go beyond their first innovation. They pursue large orders for their product, and the benefits of scale, rather than moving on to the next innovation. According to Prof. Chandra, this is contrary to their natural competitiveness that lies in innovation and flexibility. Firms "reverse engineer" the products of others, but they do not work on improving the product or the process through which it is manufactured. Big firms have predominantly restricted their innovative activity to practice improvement. Firms do not display adequate process thinking and fail to embed innovation in the organization. Prof. Chandra is concerned that they don't work enough with each other. There is evidence of this problem in the energy sector. No power utility wants to try out new technologies developed by Bharat Heavy Electricals Limited even though these technologies may solve their persisting problems. They say, "We don't want to be guinea pigs."

A culture of debate is not encouraged and questioning is frowned upon. Adequate research capacity is not created, and many observers feel that there is too much money chasing limited research skills. In the 1950s and 1960s, universities were robbed of their qualified faculty to staff India's network of public research laboratories; today, universities are starved of funds and positions lie vacant or are staffed by temps. There is also a shortage of qualified faculty available because most individuals are unwilling to make a huge monetary sacrifice to join a teaching career.[20]

Though there are capable firms in every industry, most industries lack depth. Government officials involved with technological support schemes told me that their experience is that few industrial sectors have more than one or two firms that are capable of doing high quality research and development. Such a lack of depth is seen in the academic sector as well where there are typically only a few experts in each field. This lack of depth hampers the creation of a genuine and competent peer group to whom projects can be referred for appraisal.[21] Professional bodies of scientists and engineers have circumscribed their agendas and do not debate such issues of wider significance.[22]

There remain many barriers in the path of entrepreneurs trying to set up high technology firms. Given the administrative heritage of our large firms, there is strong reason to believe that our best bet towards creating a vibrant high technology industrial base is through small firms. Yet, start-up finance is difficult to come by, government support schemes for technological innovation are biased against firms that lack a track record, and good technology business incubators are few and far between. There are not enough high technology manufacturing facilities for small volume production that would help start-ups develop prototypes and make initial production deliveries.[23] Testing facilities are also not easily available for hire outside the metropolitan cities. There is inadequate information available about new opportunities. Collaborative working with large firms is difficult because of cultural differences – large companies tend to see smaller ones as ancillaries and do not help them develop their capabilities.[24] The absence of a social security net makes entrepreneurship seem risky. Though the image of entrepreneurs in society has improved thanks to the sterling performance of entrepreneurs in the information technology sector[25], many families see a good job as a safe bet. The failure and closure of the Over the Counter Exchange of India (OTCEI) robbed small firms of an avenue to create a market for their stock.

Organizational Barriers

In a world of complex technologies, it is unlikely that path-breaking innovations will be created by the lone inventor. Much of contemporary innovation takes place within the

boundaries of a corporation. How well placed are Indian corporations to undertake the task of innovation? Being a part of a society that does not fully support knowledge and innovation, it is not surprising that Indian corporations also suffer from a number of problems in this regard.

Organizational barriers start from the top. Lack of ambition deprives the firm of the energy and stretch to initiate and complete innovation projects successfully.[26] How many companies have the advantage of being led by a Parvinder Singh who had the vision and confidence to position Ranbaxy as a research-based pharmaceutical company? Particularly when Ranbaxy had investment opportunities in India that possibly offered better returns in the short term? Knowledge creation and innovation typically have long-term payoffs and it is not surprising that many CEOs shy away from going down that path. One of the reasons that Indian companies keep away is that they have seen very few Indian companies succeed on that track. Ranbaxy may ultimately succeed but there is no certainty that it will. On the other hand, Indian companies have succeeded through incremental improvements and organizational innovations (Tata Steel and Infosys are companies that come to mind). But where is the example of a company that has grown rapidly and profitably on the back of a new product or technology? The propensity to follow the business model of successful companies is another barrier to innovation.[27] Hundreds of software companies tried to imitate Infosys and Wipro rather than try and evolve their own unique, competitive business models. This trend is accentuated by investors (individual and institutions) who are comfortable with the known and successful.

When resources (particularly money) are scarce, it is natural to focus on investments with quick returns and, preferably, low risks. Capital continues to be scarce in India, though you would not believe it if you saw the number of new cars on the roads or the number of apartments under construction. To be more accurate, there was a long period when capital was actually scarce and because of this expensive. Today, capital does not find its way to the right uses. Banks would rather invest in government securities than lend money to their customers! And venture capital, after a brief flourish, is again difficult to find.

Technological or product innovation can mean a move towards areas in which the owners lack knowledge. They are thus handicapped in decision-making and become more dependent on technologists to take decisions. Many managements are uncomfortable with this loss of control. This discomfort with technology and a perception of loss of control is a further barrier that inhibits owners of family businesses from committing resources to technology development. Reflecting the ambivalence towards R&D and technology, board-level representation for the R&D function is rare in the private sector. Further, few Indian companies have business managers with a deep understanding of technology or technology managers with business savvy.

For manufacturing companies, inadequate investment in plant and machinery, outdated production tools and inadequate use of computers on the shop floor impede manufacturing improvements.[28] R&D departments, if they exist, often lack credibility. Firms fail to develop a process orientation. Failure to embed innovation in the organization makes things worse.[29] Commercialisation costs tend to be under-estimated, and product development skills weak. Development cycles are too long and this is compounded by shifting priorities.[30]

Organizations lack the right people and skills to do truly innovative work. While a part of the blame for this lies with the educational system, firms are also responsible – they do not develop enough skills in-house and do not invest enough in training. Frustrated by the difficulties in managing people and employee turnover, many Indian companies particularly in the newer industries such as software, have sought to create "people-independent companies." Yet, anywhere in the world, major innovations are dependent on having a team of highly charged and capable individuals. Given the importance of domain skills and deep competencies, it is unlikely that cutting edge products can be built by ephemeral developers. A related knowledge management issue is that firms tend to capture explicit knowledge and not the tacit knowledge that is often the basis of path-breaking innovation. It is difficult to transfer tacit knowledge and one way of keeping

tacit knowledge in the organization is by retaining key individuals. Innovation and the "people-independent corporation" simply don't go together.

Though many of the new organizations in domains such as software and telecommunication have flat organizations, hierarchical, bureaucratic structures, and lack of creative performance management systems are barriers to innovation in older companies.[31] The perceived importance and power related to ascending the organizational ladder makes people aspire to be managers at a young age. While it is not surprising that many employees aspire to managerial positions in a society where prestige is linked to hierarchy, managerial positions in India are often accompanied by a distancing from technical work. This adds to the difficulties in building a genuine innovation culture.

In addition to the problems related to hierarchy discussed above, public research organizations have their own specific problems. They are not adequately goal-oriented.[32] They are reluctant to categorise projects as successes or failures and derive lessons from their experience. Sometimes their mental models are inadequate – e.g. a prominent research organization believes that project management is the sole driver of success.

Even leading academic institutions lack a strong research culture. They are highly teaching-oriented. This problem is particularly acute in private colleges. Many university departments do research to meet the requirements of the University Grants Commission, and not because of a genuine interest in research. Few institutions provide avenues for professors to commercialise their research,[33] and professors are bound by rigid service rules. Accreditation and external review mechanisms are weak, and there is little pressure on institutions to increase their research output or collaborative work with industry.

Government-related Barriers

If India has not fulfilled its innovation potential, is the government to blame? As mentioned earlier, some scholars like Tyabji lay the blame squarely on the outlook of the

Indian business house, which he sees as still being largely trading-oriented. Yet, many of the people I interviewed thought that the government could do more to support innovation in industry. For an influential part of the government, the reason for lack of support is philosophical and ideological – these economic policy-makers do not believe that it is government's role to support industry. In their laissez-faire approach, they see government's role as limited to removing the barriers to industrial activity and putting in place a minimalist regulatory structure. For others in government who lack the interest or stamina to help build innovative capabilities in industry, such ideological arguments provide a convenient smokescreen!

In India, the government has historically been the principal funder of research and development. A large part of this government-funded work has been done within governmental organizations. However, these organizations have rarely been allowed the flexibility to perform their tasks effectively. Compensation levels are tied to the civil service scales making retention of high performers next to impossible in an environment in which new multinational R&D centres are being set up. Incentive compensation is almost non-existent. The governmental system also impedes organizational flexibility by preventing laboratories from setting up commercial arms easily or morphing into commercial enterprises when appropriate. This is in contrast to China which has attempted to alleviate the problem of transferring technology from laboratory to enterprise by encouraging the transformation of laboratories or parts of labs into commercial organizations.[34] Ownership may rest legally with the Chinese government, but enough flexibility is given to the S&T enterprises to find their own commercial feet. Taiwan is another country where national laboratories have been used as a dynamic instrument of national innovation policy and spun-off many prominent firms including semiconductor giant TSMC.

The administrative system has more pervading effects on innovation. The bureaucratic system has tied itself up in knots, placing apparent adherence to process (or should we say "procedure") way above effectiveness or efficiency. I refer to this as "apparent" because this is one of the persisting ironies of governmental functioning in India – a

façade of fealty to process, but a reality of endemic corruption. This over-emphasis on process over results impacts the innovation process in multiple ways. Rigid pre-qualification or experience clauses in government procurement keep out new technologies and local innovation and result in failure to procure indigenously developed products that were specially developed to suit Indian needs and applications. An aversion to risk (what one respondent referred to as a lack of alignment between risks and benefits) in support of innovation favours the old and established over the young start-up that really needs the money. Long decision cycles adversely impact even projects of national significance like the Light Combat Aircraft. Funds are spread too thinly over multiple projects resulting in disproportionate under-performance. Further, recent work by Chandrashekar and Basavarajappa[35] and Ashok Parthasarathi[36] shows that resources for science and technology in India have not been targeted towards obvious national priorities. In spite of the stated importance of intellectual property rights, IPR issues are often glossed over (one public sector executive told me that he is convinced that every proposal he submits to government gets leaked to MNC competitors). Project-related correspondence is rarely incorporated into project agreements giving rise to the possibility of enduring disputes.

Conclusion

With the opening up of the Indian economy, the lowering of import duties, and freer flows of capital and technology, Indian firms are today subject to a highly competitive environment. However, this competitive environment has not automatically translated into firms having innovation capabilities. Dozens of barriers to innovation remain, and many of these are outside the immediate control of firms. Many of these barriers are complex and a result of broader societal norms and attitudes. But it is within the power of the government, industry chambers, professional bodies, educational institutions and standards organizations, to start addressing these issues. Firms have their task cut out as well to address the barriers which are under their immediate control.

In the a subsequent paper, we will identify the agenda for change – how can we accelerate India's progression towards creating an environment conducive to innovation leading to knowledge creation, diffusion, and application?

In the preceding sections we have discussed the barriers faced by the formal innovation system. Of course, for India to achieve its fullest potential, the entire population has to be a part of the knowledge economy. Socio-economic development is an incredibly complex process, and outside the scope of our current work.

Notes & References

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[1] This paper draws on much of my previous work. In particular, see Rishikesha T. Krishnan & Ganesh N. Prabhu, "Creating Successful New Products: Challenges for Indian Industry," *Economic & Political Weekly*, July 31, 1999, pp. M114-M120.

[2] Interview with Y.S. Rajan, Adviser (Technology), Confederation of Indian Industry, 19th October 2004.

[3] Personal correspondence with Nasir Tyabji

[4] Dinesh Abrol "Post-TRIPs Technological Behaviour of the Pharmaceutical Industry in India," *Science, Technology & Society*, Vol. 9, No. 2, July-December 2004, pp. 243-271.

[5] For an investigative report on this incident, see "Herbal Petrol Case" at the website of the Central Bureau of Investigation http://cbi.nic.in/case1.htm (downloaded on 11th February 2006).

[6] Sara Robinson "New Method to solve key problem in math," downloaded from www.nytimes.com on August 8, 2002.

[7] Interview with Pankaj Chandra, Indian Institute of Management Ahmedabad, August 23, 2004.

[8] For a hard-hitting revelation of the gap between stated beliefs and beliefs in action, see Meera Nanda "Is India a Science Superpower?," *Frontline*, 23rd September 2005. Downloaded from http://flonnet.com

[9] See www.milkmiracle.com for the claims of those supporting the miracle.

[10] For a critique of these tests, see "India: Fire trial of chastity," a part of Bulletin #100 of Rationalist International, http://www.rationalistinternational.net/archive/en/rationalist_2002/100.htm downloaded on 11th February 2006.

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[12] See Linsu Kim *Imitation to Innovation: The Dynamics of Korea's Technological Learning*, Harvard Business School Press, 1997.

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[14] The importance of experimentation is emphasized in Stefan H. Thomke *Experimentation Matters: Unlocking the Potential of New Technologies for Innovation*, HBS Press, 2003.

[15] George Santayana, *The Life of Reason*, Volume I, 1905. From http://www.quotationspage.com/quotes/George_Santayana/ Downloaded on 11th February 2006.

[16] See Bhanoji Rao "Standards of Teaching and Research in Economics," *Economic & Political Weekly*, 1st May, 1999; V. Subramanian "Doctoral Work in Social Sciences: Some Reflections," *Economic & Political Weekly*, 16th October 1999; Biswanath Debnath "Crisis of Indian Anthropology," *Economic & Political Weekly*, 30th October 1999; Rajen Harshe & Sujata Patel "Identity Politics & Crisis of Social Sciences," *Economic & Political Weekly*, 8th February 2003.

[17] Interview with Anil K. Gupta, Indian Institute of Management Ahmedabad ,August 24, 2004.

[18] A heavyweight project manager is the leader of a cross-functional team formed to take on an ambitious new development project. The heavyweight project team enjoys considerable autonomy and devoted

resources, though the members of the team may still retain some links to their functional departments. For a review of different product development team structures, see K.T. Ulrich and S.D. Eppinger *Product Design & Development*, McGraw Hill, 1995.

[19] Interview with Pankaj Chandra, Indian Institute of Management Ahmedabad, August 23, 2004.

[20] Reflecting this shortage, the All India Council for Technical Education has permitted retired faculty to work till the age of 65.

[21] Interview with Satyajit Rath, National Institute of Immunology, August 12, 2004.

[22] Interview with P. Balaram, Indian Institute of Science, August 6, 2004.

[23] See Rishikesha T. Krishnan "Product Development: Learning from 'Reva' Experience," *Economic & Political Weekly*, May 11, 2002, pp. 1787-1789.

[24] Rishikesha T. Krishnan & Ganesh N. Prabhu, "Creating Successful New Products: Challenges for Indian Industry," *Economic & Political Weekly*, July 31, 1999, pp. M114-M120

[25] See P.D. Reynolds, et.al., *Global Entrepreneurship Monitor 2000 Executive Report*, Babson College and London Business School.

[26] For a comprehensive discussion of the importance of ambition and vision in changing Indian companies, see Sumantra Ghoshal, Gita Piramal, and Christopher A. Bartlett *Managing Radical Change*, Penguin/Viking, 2000.

[27] Institutional theory argues that imitation is rational. See P.J. DiMaggio and W.W. Powell "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields," American Sociological Review, Vol. 48, 1983, pp. 147-160.

[28] Interview with Pankaj Chandra, Indian Institute of Management Ahmedabad, August 23, 2004. Inadequate investment in plant and machinery is corroborated by the McKinsey Global Institute study of the competitiveness of the Indian economy.

[29] Interview with Pankaj Chandra, Indian Institute of Management Ahmedabad, August 23, 2004.

[30] In one company that I studied, of 22 development projects undertaken during a fifteen month period, there was an average delay of 3.5 months and a maximum delay of nine months in launching products. The commercial consequences of these delays were severe as the delayed launches meant missing a commercially important target date.

[31] See *Making Indian Manufacturing Globally Competitive*, Accenture, 2002.

[32] I started work on a strategic planning project with an Indian public research laboratory in July 2004. But even a year later it was difficult to get research groups within the laboratory to prepare a long-term road map.

[33] An exception is the Indian Institute of Science, Bangalore, where professors have started companies in information technology and biotechnology.

[34] Q. Lu *China's Leap into the Information Age: Innovation and Organization in the Computer Industry*, Oxford University Press, 2000.

[35] S. Chandrashekar & K.P. Basavarajappa "Technological Innovation & Economic Development: Choices & Challenges for India," *Economic & Political Weekly*, Vol. 36, No.34, August 25, 2001, pp. 3239-3245.

[36] Ashok Parthasarathi "Priorities in Science and Technology for Development: Need for Major Restructuring," *Current Science*, Vol. 82, No. 10, May 25, 2002, pp. 1211-1219.