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Constructing a Sustainable Technological Platform in India

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In this paper, the author investigates how India has strived to construct a sustainable technological platform. The study highlights that India's intended policy since the 1980s was to import foreign technology, and to encourage its exploitation and localization by the private sector. Reflective analysis suggests that the policy intentions were only partly met, as the demands of development exceeded the policy accomplishments. For sustainable technological platform, the emphasis appears to be now shifting to the development of meso-organizations for discovering and connecting the local cultural knowledge with the national and global value chains.

Keywords: **Foreign Technologies and Techniques, Policy Reforms, Information Revolution, Computer Industry**

Introduction

Many scholars have looked at the process of technological learning in the emerging markets (e.g. Westphal, Kim & Dahlman, 1985; Lall, 1987). These studies suggest that the emerging markets should rely on imported inputs and export-oriented growth, and should do so rather heavily during the early phases of technology accumulation. For rapid growth, they need to exploit and build upon the local capacity to assimilate, absorb, and improve upon the foreign technology.

Several problems, however, are associated with the foreign-technology based development, which may lead to a substantial volatility in the economic growth of the nations. The experiences of the East Asian nations over the past decade stand witness to some of these problems. First, foreign technology and techniques may not be appropriate for the climate, culture, and resources of an emerging market. International technologies tend to be capital and scale intensive, and require larger markets and sophisticated infrastructure to support them. Similarly, international techniques tend to be more appropriate for large, professionally managed firms, for activities that can be systematized and routinized (Nelson & Winter, 1982). When applied to activities that require custom applications, they tend to result in rapid escalating costs, and require significant market premium to cover these costs (Gupta, 1998).

Second, foreign technology and techniques are not readily tradable and transferable to the emerging markets. The recognition, application, and improvement of foreign technologies and techniques require substantial prior knowledge and research experience (Cohen & Levinthan, 1991). Technological growth tends to be historically conditioned. Effective improvement of technology is feasible only when a nation has a substantive prior base in related technologies and techniques, and in the disciplines associated with them (Cantwell, 1989). The original developers of international technologies and techniques tend to enjoy well-established markets, and well-endowed resources and capabilities, for rapid, continuous innovation (Porter, 1990). The high costs of technology transfer and assimilation make it difficult for the emerging markets to successfully catch up with the original developers, using the technology and techniques traded or copied from the original developers (Teece, 1977). Also, the original developers have little incentives to transfer their entire package of technology and techniques. One time transfer of technology and techniques also has limited developmental benefits for the emerging markets,since the local firms are rarely able to develop capabilities for fundamental innovation and engineering based on a single generation of know-how transfer. Such capabilities are generated over a period of time by working on multiple successive generations of inter-related know-how (Cantwell, 1989).

Third, only the larger firms in the emerging markets have reputation or resources to be able to purchase foreign technology and to invest in learning of the foreign techniques. Often, it is the government and government supported institutions that seek to play a major role in financing the imports of foreign technology and techniques. Since there are significant subsistence and developmental demands on the foreign exchange reserves of the emerging markets, the governments tend to limit private sector initiatives that strive to import even small amounts of foreign technology (Chandra, 2002). The government-supported institutions have limited, well-defined roles, and are usually unable to invest into the development of complementary set of resources needed to commercialize their versions of the imported technologies.

Given these problems, it is imperative to examine an alternative model that is based on the indigenous endowments of the emerging markets, to allow for a more reciprocal, comprehensive, and sustained exchange of techniques and technologies with the foreign firms, and to enable a broader participation of private firms and individual entrepreneurs in the development process.

Is it feasible and prudent for the emerging markets to set such a vision for their developmental model? In this article, we investigate the experiences of India with the creation of a sustainable technological platform. The analysis is organized chronologically into two eras.

Initiatives to Create A Sustainable Technological Platform

The pattern of initiatives to create a sustainable technological platform is divided broadly into two periods: Pre-1995 (Informatics Revolution), and Post-1995 (Knowledge Revolution).

1981-95 – Informatics Revolution

Just as India suffered from food crisis in mid-1960s, the early 1980s saw India in the midst of a major employment crisis. In light of limited resources, the Sixth Five Year Plan (1980-85) pioneered an integrated rural development model for greatest and deepest possible impact on employment. The problem of educated unemployment in the urban centers was more difficult to tackle, but a series of events unfolded to make informatics, and in particular software, a priority solution for the nation.

Policy Reform in Informatics

In 1984, India's new Prime Minister Rajiv Gandhi, Indira Gandhi's son and Nehru's grandson, laid a vision of taking India into the twenty-first century through a major emphasis on technological advancement, with a central role for the electronics industry including consumer electronics and software.

Rajiv Gandhi rallied political support for liberalizing the emerging computer industry, and for the entry of private firms and of joint ventures with foreign firms. A November 1984 Computer Policy recognized software as an industry, making it eligible for fiscal incentives and bank credit. Body shopping, or the provision of labor-intensive, low value-added programming services, such as coding and testing, at client sites overseas, were also recognized as valid exports.

Educational policy went in hand with the policy reform. The government permitted private investment in IT training, for both short-term specialized courses as well as longer-term basic courses.

Also, the government policy to computerize its departments and enterprises generated large and complex assignments for the local firms, and became a key catalyst for development of software industry. The most notable was the automation of state-owned railways reservation. The average waiting time for the passengers was reduced to less than 20 minutes (Mulhearn, 2000). While the railway reservation project resulted in a dramatic mind set change in favor of the personal computers, in 1985, the Rangarajan Committee decided to computerize all public sector banks, and to use Unix and the Motorola 68020 chip. And immediately, private companies – starting with HCL – raced to introduce Unix systems, ahead of the companies in other nations (Dataquest, 2002).

Evolution of the Private Informatics Industry

The exports of software from India had started in 1974, reaching $4 million in 1980, $28 million in 1985, and rising to $481 million by 1995. Given the weak telecommunication infrastructure, the Indian firms found it more difficult to do large volume body shopping work from India, though the intro level programming salaries in India were only a tenth of those in the US (Mulhearn, 2000).

Rajiv Gandhi invited foreign multinationals, starting with Texas Instruments in 1986, to set up software development units in India through a 40%/51% joint venture, so that they may be able to sell an entire value-added hardware platform in India. By 1992, nearly all major Indian firms had formed a joint venture with a major MNC; though by 2000, most joint ventures had been dissolved and MNCs and local firms were operating largely independently (Dataquest, 2002). In the interim, there was a growing demand for the professionals. Over the 1990s, every year, more than 67,000 computer science professionals were trained by the state educational institutions, and another 200,000 by private institutes (NASSCOM 1999).

With the post 1984 informatics revolution, computer production nearly quintupled, hardware exports more than quintupled, and software exports more than tripled by 1989. In 1989, Indian IT industry's revenues totaled Rs. 10 billion (as opposed to Rs. 750 million in 1980), with HCL reaching the Rs. 1 billion mark.

The 1991 Economic Crisis and Liberalization

In absence of broader reforms, the liberal import regime of the 1980s soon culminated into a major national economic crisis. In 1991, India, after being forced to seek balance of payment aid from the IMF, embarked upon major economic reforms, including dismantling of the 'license raj' system. Tariff rates were reduced from 128% of import bill in 1991, to 29% by 2002 (Salgado, 2003).

Economic Performance

The reforms of the 1990s accelerated the trend of Indian companies doing onsite as well as offshore software projects, so that the share of services in total Indian exports rose from 20% in 1990 to more than 30% in 2002, with a rapid growth in workers' remittances and in IT exports (Thirwell, 2004). The share of services – including hotel & tourism, consulting services, power generation, and telecom – in India's inward foreign direct investment also rose from 5% in 1990 to 59% during 1991-97 (Thirwell, 2004).

1996- – Knowledge Revolution

Science and Technology Policy

During the second half of the 1990s, IT sector's compound annual growth rate topped 40%, against less than 7% for the nation. The software sector alone grew more than 55% annually, and accounted for $3.9 billion of revenues in 1999, constituting 65% of India's total IT revenues. By 2000, a majority of the Fortune 500 companies outsourced IT services from India.

Until 1990s, most public sector R&D institutions had few links with the industry, and were totally dependent on the government for their financing (Krishnan, 2003). Since mid-1990s, a major change occurred, as these institutions applied for international patents, and sought to generate commercial funds by licensing their know-how. Table 1 shows the public sector led in the number of patents and consulting services rendered, and shared honors with the private sector in the imports substitutes developed; the private sector, on the other hand, excelled in the development of new products and new design prototypes. However, out of 8,954 applications filed for patents in India during 1998-99, only 2,247 were by Indians (Sadasivan, 2005)

R&D Output	Institutional Sector		Industrial Sector		Total
	Central Sector	State Sector	Public Sector	Private Sector	
Patents Sealed	300	11	53	187	551
Products developed	531	214	546	6088	7379
Processes developed	289	215	138	1812	2454
Import Substitutes developed	192	11	1528	1753	3684
Design prototypes-developed	343	66	181	1497	2087
Consultancy Services rendered	8602	43511	77	5637	57827

Table 1 - R&D Output by Sector, 1997-98

Despite these developments, studies suggest that in the early 1990s private sector firms put greater emphasis on importing technology (See Table 4), than on the internal research and development. The larger firms, because of their better resources and funds, tended to be more active in importing foreign technology. Increasingly, foreign subsidiaries became more dominant in introducing new technology for expanding into new product areas. As a result, even the leading Indian firms found it difficult to access latest technologies, as the MNCs sought to directly access the Indian market either through trade or local production, instead of licensing these technologies to local companies (Vishwasrao & Bosshardt, 2001).

Year	Foreign collabo-rations approved (No.)	Foreign investment approved ($ million)	Actual FDI ($ million)	Lumpsum payments approved ($ million)	Actual technical payments ($ million)	Capital goods imports ($ million)
1991	976	232	154	429	251	4665
1992	1520	1336	232	784	139	3724
1993	1476	2842	573	1183	318	5343
1994	1854	4526	1048	733	210	6368
1995	2337	9902	2071	2185	397	8589
1996	2303	10321	2969	758	458	8537

Table 2: Indicators of Foreign Technology Acquisition by India

Low levels of R&D by domestic firms became a key policy concern during this period. Studies indicated the significance of such R&D in learning from and absorbing not just foreign, but also domestic know-how. Kathuria's (2001) study of more than 300 firms over 1975-89 found that the presence of MNCs often led to larger gaps in efficiency between the MNCs and domestic firms. However, the domestic firms bridged these gaps when they had strong R&D capabilities, and such capabilities were positively related to the level of a firm's export activities. Other studies showed that during the 1980s, the domestic firms that purchased more of domestic or foreign technologies tended to have higher R&D expenditures (though not vice versa), but during the 1990s technological collaborations were no longer associated with higher R&D expenditures (Raut, 1988; Kartak, 1997; Vishwasrao & Bosshardt, 2001). In fact

Period	Number of new R&D Units
Before 1950	24
First Five Year Plan (1951-56)	13
Second Five Year Plan (1956-61)	27
Third Five Year Plan (1961-66)	48
Annual Plan (1966-67, 1968-69)	37
Fourth Five Year Plan (1969-70)	154
Fifth Five Year Plan	196
Annual Plan (1979-80)	38
Sixth Five Year Plan (1980-85)	278
Seventh Five Year Plan (1985-90)	243
Annual Plans (1990-91, 1991-92)	94
Eight Five Year Plan (1992-1997)	95
Not Available	68
Total	1315

Table 3: New R&D Units Over the Years

the number of new R&D units created fell significantly during the 1990s, as compared to the 1980s, as shown in Table 3.

To facilitate research and development, the government introduced several programs to support the absorption of imported technologies, develop, demonstrate, and commercialize indigenous technologies, and encourage technology-based entrepreneurs. The share of private sector in national R&D expenditures, consequently, rose to 20-25% during the late 1990s, as opposed to 15-20% during the early 1990s (Table 4). Many private companies, such as Reliance Industries, started taking up R&D formally.

Science & Technology		% of *GNP*	Composition of R&D		
Year	Expenditures (Rs. Million)		% Central	% State	% Private
1958-59	229	0.16	95	4	1
1965-66	684	0.27	91	5	4
1970-71	1396	0.33	81	9	10
1975-76	3567	0.47	81	7	12
1980-81	7605	0.58	76	8	16
1985-86	20688	0.83	80	8	12
1989-90	37257	0.86	77	9	14
1994-95	66224	0.73	71	9	20
1998-99	129015	0.81	64	10	26

Source: Department of Science and Technology (2002)

Table 4: Growth of India's Science and Technology investments

Socio-economic Performance

By the late 1990s, the variability in the growth rate and the volatility of inflation rates declined significantly compared to the earlier periods, indicating that the nation's development process was now on a remarkably resilient footing.

Biodiversity and Sustainability Initiatives

In 1998, UNDP helped India prepare the First National Report to the Convention on Biological Diversity. A sense of urgency prevailed with several widely publicized cases of international biopiracy of traditional knowledge of India. Patents had been issued in the US and European union, for instance, on wound healing properties of turmeric, hypoglyceimic properties of bitter gourd, and fungicidal properties of neem, all of which have been part of India's traditional knowledge. The National policy on biodiversity sought to "Ensure benefits to India as country of origin of biological resources and to local communities and people as conservers of biodiversity, creators and holders of indigenous knowledge systems, innovations and practices" (Government of India, 1999). Towards this end, the CSIR's Department of ISM&H (Indian System of Medicine and Homeopathy) created a navigable electronic computerized database of documented traditional knowledge. (Srivastava, S., 2002).

Building on the successes of the Honey Bee Network, the government of India established the National Innovation Foundation in October 2000 to provide institutional support in scouting, spanning, sustaining and scaling up of grassroots innovations, and to enhance technical competence and self-reliance of grassroots innovators, through establishment of green venture promotion funds and incubators and by building linkages with science and technology experts, entrepreneurs, and corporate world.

International Comparisons

Despite considerable progress, India still lags behind major developing nations on most measures of globalization and socio-economic development. Table 5 reports competitiveness for a sample of large developing countries that have liberalized their economies. As is evident, India's growth competitiveness index is lower than China, Mexico and Poland, and is higher than only Egypt.

(Scale of 1 to 7), 2003	India	Egypt	China	Mexico	Poland
Growth competitiveness index	3.90	3.84	4.19	4.12	4.15
1. Macro-economic environment index	3.75	3.70	4.56	3.74	3.83
a. Macro-economic stability sub-index	4.36	4.02	5.05	3.81	4.04
b. Government waste sub-index	3.56	3.44	3.66	2.96	2.71
c. Credit rating sub-index	3.74	3.34	4.49	4.39	4.54
2. Public institutions index	4.26	4.18	4.33	4.35	4.17
a. Contracts and law sub-index	4.65	4.23	3.81	3.70	3.59
b. Corruption sub-index	3.86	4.14	4.84	5.00	4.75
3. Technology index	3.68	3.64	3.67	4.26	4.44
a. Innovation sub-index	2.06	2.71	1.97	2.25	3.20
b. Information & communication technology sub-index	2.87	3.13	3.42	3.95	4.36
c. Inbound Technology transfer sub-index	5.31	4.63	4.57	5.35	4.97

Table 5: India's Comparative Global Competitiveness Index and its Components

Guided by the experiences in the software sector, increasing attention has during this decade been placed on securing a place for India in international research, through participation in the international research value chains. It is believed that India offers and should offer a range of human resources for the increasingly complex multinational operations, and gain a special place for global contract research. It would then be able to graduate from participation in part of the system, and then to bigger systems; helping Indian firms participating in these sophisticated value-adding chains to build up their internal core technological capabilities rapidly and to catch up (Rajan, 2001).

Discussion

This article was analyzed chronologically to aid identification of the origins, formation, and development of the indigenous endowments through internal and external linkages.

In the first period (pre-1995), the nation opened up the economy gradually, and invited private firms to exploit the infrastructure and capabilities created in the public sector. The private firms were able to discover innovative and creative linkages for productively exploiting the public sector infrastructure, to rapidly move on the learning curve of servicing a diverse base of costly foreign technology, and to confidently expand overseas to offer onsite maintenance, testing, and other software and information technology services to the foreign companies. Further, the private sector, after being allowed into the telecom equipment manufacturing, became an important partner helping the government organizations to extend data communication, nation-wide networking, and internet services to the software and other firms. The foreign multinationals helped to catalyze the developmental process, for instance by setting up first offshore software development units in India during the mid-1980s that became certificates endorsing India's capability for reliable offshore development. The multinationals also inspired a strong quality movement, for instance, Motorola's Indian software subsidiary became the first SEI CMM Level 5 certified facility in India. The private firms lagged behind the multinational subsidiaries in terms of their efficiency, especially when they did not conduct much R&D, yet were able to generate rapid gains in efficiency throughout the period. Many private firms engaged in the internal R&D to absorb and exploit foreign technologies, services, and capital goods, or as the government liberalized the market,sought to simply rely on foreign collaborations for accessing technologies.

In the second period (post-1995), the strategy of large private sector firms of relying on the imported technologies, services, and capital goods appears to have run into limits, as the gains in efficiency realized during the previous period matured. Many technology collaborations with foreign firms have fallen apart. Some large private sector firms, such as Reliance, have started putting emphasis on the internal R&D, rather than continuing to depend on the international imports of technological know-how. The public sector firms, on the other hand, have shifted their priorities to making available their own internal R&D results to the firms, not only locally but also globally. The foreign firms have sought to exploit their own know-how by encouraging their Indian subsidiaries to be first to introduce new products – which stands in a stark contrast with the situation in the first period when the foreign firms offered only old and antiquated products in India, and that too with high mark-ups and with high maintenance fees. The domestic firms appear to have attained a high level of maturity in their process capability. In the software sector, more Indian firms are certified at the highest level of process capability maturity than all the overseas firms put together. In most other sectors also, domestic firms have been able to, possibly by virtue of their matured process capability, retain a dominant share of the market, except where they consented to be acquired by the foreign multinationals (as in soft drinks), or where the foreign multinationals have operated in India for a long period in so much they are deemed to be virtually domestic (for instance, Unilever as in detergents and cosmetics).

There has been a shift in the role of the government from a supporter of innovations by well managed private sector enterprises, and then to governance and organization of the distributed knowledge in diverse communities. "The emerging role for the developmental state in the globalized economy is the networking role or support of government to enterprises......to penetrate the linkages of deep integration.....The final results will depend much less on specific policies than on the policy implementation capability of governments and the kind of social organization and governance mechanisms that they build for an economy increasingly dependent on foreign markets, finance, production and technology networks." (Radosovic, 1999)

In the earlier paradigm, the government led basic innovations for the defense and other strategic sectors, and the spin offs for commercial applications, if any, were found later. In this paradigm, the costs of the technologies were huge, and initially technology-rich products were marketed to the corporate sector and targeted at customers with higher incomes and technological savvy. In the new paradigm, which evolved over the 1980s and the 1990s, the governments began sourcing a number of defense systems from the regular commercial systems. The quality of the commercial systems improved so dramatically that new products became accessible more widely to the consumers, not just to the businesses. The governments began seeking cooperation of the private sector for developing dual use technologies, i.e. technologies that could be used for both civil and defense and other strategic purposes (Rajan, 2001). In the fourth phase, yet another paradigm is in making. The academic, research, and the development sector (community groups, non-government organizations) is discovering diverse know how of the local communities, and the commercial value of this know-how is being recognized. The government is seeking to promote awareness of this local knowledge, and to build capacities for national and international exploitation of this knowledge. Thus, over the four phases, there has been a 180 degrees turn in the targeted source of knowledge and innovation.

An integrated approach needs to emerge. There is scope to forge inter-national and multi-national strategic alliances in technological growth, in a way that strengthens the ability to be independent as well as the ability to pursue greater inter-dependence demanded by sophisticated and complex futuristic technology systems. The private sector can help speed and efficiency of action, while the meso development organizations can help broaden and deepen the technological base for exploitation.

In the first phase, the thrust was on nurturing innovative organizations in the private sector, through public sector cooperation and guidance. In the second phase, however, there is a growing awareness about a new category of innovation - grassroots or micro innovations, which involve artisans, farmers, women in households, slum dwellers, tribals, and other unsung heroes who never obtained credit for their creativity. Micro innovations are shared largely through informal networks, though increasingly non-government organizations are seeking to scout, document and commercialize these innovations.

There also needs to be an emphasis on increasing the diversity and depth of micro technological base. The growth of innovation chain requires recognizing, supporting, enhancing, and directing diversity in social, scientific, and management education, mass media, public awareness, and in the art of teaching, learning, and leveraging social, scientific, and management knowledge. Multi-, cross-, and inter-disciplinary knowledge initiatives must be promoted towards this end through stronger participation of the institutions of higher learning. The academic linkages with the corporate, government, non-government, and community organizations and members for developmental purposes are critical to perpetuating technological growth system.

Conclusions

In this paper, the author sought to examine the effectiveness of a developmental model based on institutional technology transfer, where technology flows from overseas to the private sector. The analysis suggested that this model is more viable for the larger firms, who have resources to do complementary research and development for adapting the foreign know-how and capital goods to the local climate, culture, and market conditions. The firms that conduct internal research and development, however, may generate and accumulate their own internal knowledge, and be able to compete with the foreign firms.

A more critical factor appears to be collaboration and strategic alliances, both between the foreign firms and the private sector, as well as between the public sector and the private sector, that helps firms gain an overall strategic awareness of the international technological, organizational, and servicing parameters, and of the national technological, organizational, and servicing endowments. Such strategic awareness allows the firms to leverage and develop indigenous endowments for world-class applications, and exchange in the international markets.

Most importantly, significant opportunities exist to uncover the deep cultural knowledge embedded within the local communities and their work practices, and to tap and develop that for solving unique and hitherto unsolved problems at the national and international levels. These opportunities hold the greatest promise for the large emerging nations, such as India, to play an active and complementary role in the international community. Further understanding and exploitation of these opportunities would allow the poor and low income workforces of the emerging nations to enjoy rapid growth in their incomes and purchasing power, by cashing in on their cultural endowments, without taking away jobs from and without pirating the knowledge of the industrial markets.

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