Indian National System of Innovation and Globalisation: Some Lessons for African National System of Innovation

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ABSTRACT

India and Africa share a common history of colonisation and some common post-independent political and socio-economic problems. Because of this, India's economic development policies and its achievements and failures since its independence in 1947 have been keenly followed in many African countries. Until recently, India's science, technology and economic policies were tuned to achieve 'self-reliance' which created an 'inward-looking' national innovation system, that aimed to build an economic system that could meet the domestic needs to the maximum level. This led to a very different experience compared that of East-Asian countries such as South Korea and Taiwan, which witnessed higher rate of growth led by export-oriented innovation system that made them internationally competitive. In contrast, the inward-looking innovation system of India faced strong criticism over the years because of its inefficiency that led to low rate of growth and relatively low competitiveness. Since early 1990s, India, like other developing countries, faced strong challenges posed by the forces of globalisation. India responded cautiously with a selective liberalisation of policy regimes aimed at transforming its national innovation system into an outward-looking system. Over the last ten years this policy shift appears to have produced mixed results. This suggests that liberalisation of policy regimes may not be enough to realise the full potential of India's innovation system. First, this paper analyses the major characteristics of India's system of innovation, its response to challenges posed by the globalisation and its overall performance. Then, it draws some lessons that are relevant to the study of African national innovation system.

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I. INTRODUCTION

India and Africa share a common history of colonisation and struggle for independence. India's independence influenced many national liberation movements across Africa. Further, both India and Africa have been facing some common post-independent political and socio-economic problems towards achieving development and modernisation. Because of this shared colonial history, India's economic development policies and its achievement have been keenly watched and to some extent followed in many African countries. After attaining independence, India was trying to find a right development model. Indian political leaders feared neo-economic colonisation by the Multinational Corporations (MNCs), as the memory of colonisation of India by the East India Company was still fresh. At the same time, the rapid industrialisation achieved by the Soviet Union through five-year plans appears to have made a big impression on them. As a result, Indian leaders, while following a Western democratic political system, decided to follow a 'mixed-economy' model where the public sector played a predominant role. India's science, technology and economic policies were tuned to achieve 'self-reliance' which until the mid-1980s was 'inward-looking'. This led to a very different experience compared to that of East-Asian countries such as over South Korea and Taiwan. However, the experiences of Indian national innovation system over the last five decades are more relevant to African system of innovation system because of common socio-economic problems such as large rural population, illiteracy, health, food and poverty.

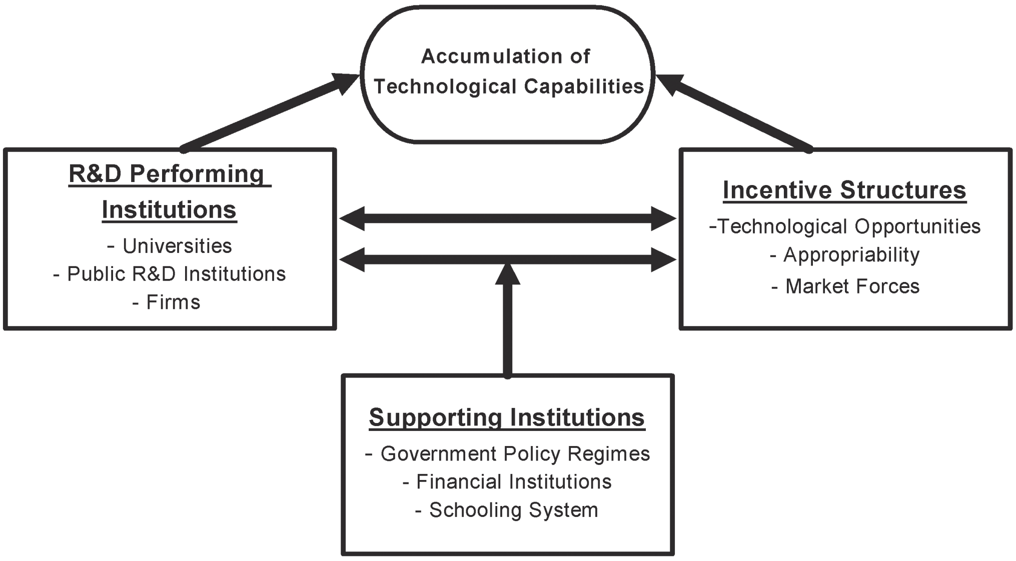
In this paper, first, we discuss the national system of innovation in the context of developing countries and then, the evolution of Indian national innovation system (Phase I – inward looking, Phase II – outward looking, duality or lopsided phenomenon) and its overall performance. Finally, we draw some lessons from India's experiences for the study of African system of innovation.

II. NATIONAL SYSTEMS OF INNOVATION AND DEVELOPING COUNTRIES

The concept of national innovation system is defined as "the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning ...in a country" (Patel and Pavitt, 1994, p.12). It helps to understand the varied nature of the process of acquiring technological capabilities not only in developed countries but also in the developing countries. To Freeman, the national system of innovation is the way "resources are managed and organised" in the pursuit of acquiring certain technological capabilities. He argued that while "the national system of innovation may enable a country with rather limited resources ... to make very rapid progress", its "weaknesses… may lead to more abundant resources being squandered by the pursuit of inappropriate objectives or the use of ineffective methods" (Freeman, 1987, p. 3).

The national innovation system encompasses institutions, laws and policies and evolves into different shapes because of the differences in "national histories and cultures including the timing of a country's entry into the industrialisation process" (Nelson, 1993, p.18). This needs to be kept in mind when we discuss national innovation systems in India and Africa. For example, Hobday argues that the process of technological accumulation and industrialisation in the newly industrialising countries such as Korea was in fact "more or less the reverse of the conventional Western models" (Hobday, 1995, p.3). The East Asian model has demonstrated that "there are many roads to success" (Lall, 1994, p.294). Above all, it strengthens the notion that individual nations evolve their own system of innovation, conditioned by various social, economic, and political factors at different stages of their history.

Figure 1: Three Major Elements of National Innovation System



As shown in Figure 1, three major elements (R&D performing institutions, incentive structures, and supporting institutions) interact with each other in an efficient national innovation system and determine the rate and shape of technology accumulation (Industry Commission, Australia, 1995). Linkages between R&D performing institutions such as firms, universities and public research institutions, influenced by the opportunities offered by the incentive structures and the role played by the supporting institutions such as financial institutions and education system, contribute to innovative performance. However, the actors or agents that determine performance in the civil and complex dual-use technologies are not necessarily the same. This can lead to two different levels of innovation performance. For example, the incentive structures which play a major role in determining the innovative performance in the case of civil technologies are either insignificant or play no role at all in determining the performance in complex dual-use technologies such as nuclear and space technology. In such conditions, there is the likelihood that one will witness uneven technological accumulation in the civil and dual-use areas within a national innovation system. Understanding of this phenomenon of 'lopsided' or 'duality' in a national innovation system is important when analysing the performance of Indian national innovation system. India appears to have accumulated a high level of technological capabilities in complex dual-use areas such as space technology and in certain civil sectors such as biotechnology and information technology (software), while it has not succeeded to the same level in many other civil sectors. The following sections trace the evolution of Indian national innovation system and analyse its achievements and failures.

Figure 2: Three Major Features of Indian National Innovation System

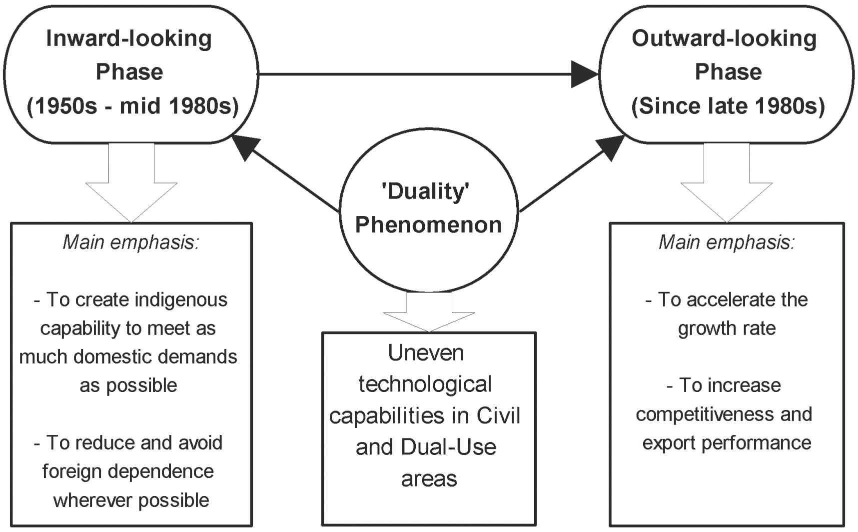


Figure 2 illustrates the three major features of the evolution of Indian national innovation system: (i) Inward looking Phase I; (ii) Outward looking Phase II; and (iii) the phenomenon of 'duality'. Indian national innovation system that evolved between 1950s and mid-1980s was driven by two major factors; (i) 'blind faith' in science and technology; and (ii) an inward-looking policy of 'self-reliance'. Jawaharlal Nehru, India's first Prime Minister declared that "science alone...could solve these problems of hunger and poverty" (Nayar, 1983, p. 252). In 1958, the Scientific Policy Resolution committed the government "to foster, promote, and sustain, by all appropriate means, the cultivation of science, and scientific research in all its aspects" (Nayar, 1983, p.288). Immediately before and after independence in 1947, India established basic science and technology (S&T) infrastructure that included a network of public R&D organisations, universities, science and engineering institutions.

The principal policy objective behind India's industrialisation effort has been 'self-reliance'. Nehru said that India could not be economically or politically independent unless it strengthened its scientific and technological capacity (Eisemon, 1984, p. 269). Indian leaders feared the domination and influence of foreign firms if free and unrestricted entry were allowed. Therefore, India's 'self-reliance' policy was defensive and inward looking rather than outward looking. India aimed to create local technological capabilities to meet mainly the domestic demands and reduce foreign dependency rather than developing an industry that should be competitive in the global market. This fundamental factor determined the shape and efficiency of Indian innovation system in Phase I. 'Self-reliance' policy influenced the development of other major elements of Indian innovation system – the incentive structures and supporting institutions, that is, financial markets, education systems and governments' macroeconomic and industrial policies. To achieve self-reliance, India implemented a number of measures such as industrial policy clearly defining the roles of private and public sectors, regulation of private investment through industrial licensing, regulation of foreign private investments, and regulation of technology imports to encourage indigenous research and development (Mascarenhas, 1982, p.4).

Until mid-1960s India did not have a technology import policy and there was little concern about technological dependence. However, between mid-1960s and mid-1970s, technology imports were regulated due to a number of factors such as problems of foreign exchange reserves, need to regulate domestic competition, and to encourage the development of applied R&D institutions. The technology import policy (1965-68) was aimed at eliminating the advantages of the use of imported technology and to encourage import substitution. This led to scale-adaptation of imported technology to suit domestic market demands. This in turn led to the development of indigenous R&D capabilities and local machine tools and industrial equipment suppliers as little or no technical assistance was received from foreign technology suppliers (Cooper, 1988, p.117). The technology import policy has helped firms to become informed buyers and by the early 1980s, India has achieved a high level industrialisation through "extensive collaboration for the import of foreign technology" (Mascarenhas, 1982, p.7). There were two major developments in the industrial sector. On the positive side, India has developed relatively a high level of indigenous technological capabilities to design and operate plants in number areas of capital and intermediate goods sectors (Mascarenhas, 1982, p. 2). On the negative side, Indian firms hardly made major innovations to their products to establish a significant and sustainable export market. They mainly produced cheap and reliable products for the domestic market and a number of firms started in-house R&D to develop such products by adapting imported technology. By the early 1970s, most of the public R&D institutions made effort to catch up with research in the developed countries and conducted research at the frontier level. Although they produced scientific knowledge and created a strong basic research base, often they did not contribute directly to help solve socio-economic problems of the country (Mascarenhas, 1982, p.2). The government's attempt to force firms to buy technology from public R&D institutions was given up in 1975 and by the early 1980s India started liberalising its policies towards import of 'new technology'.

IV. PHASE II (SINCE LATE 1980S): OUTWARD LOOKING NATIONAL SYSTEM OF INNOVATION

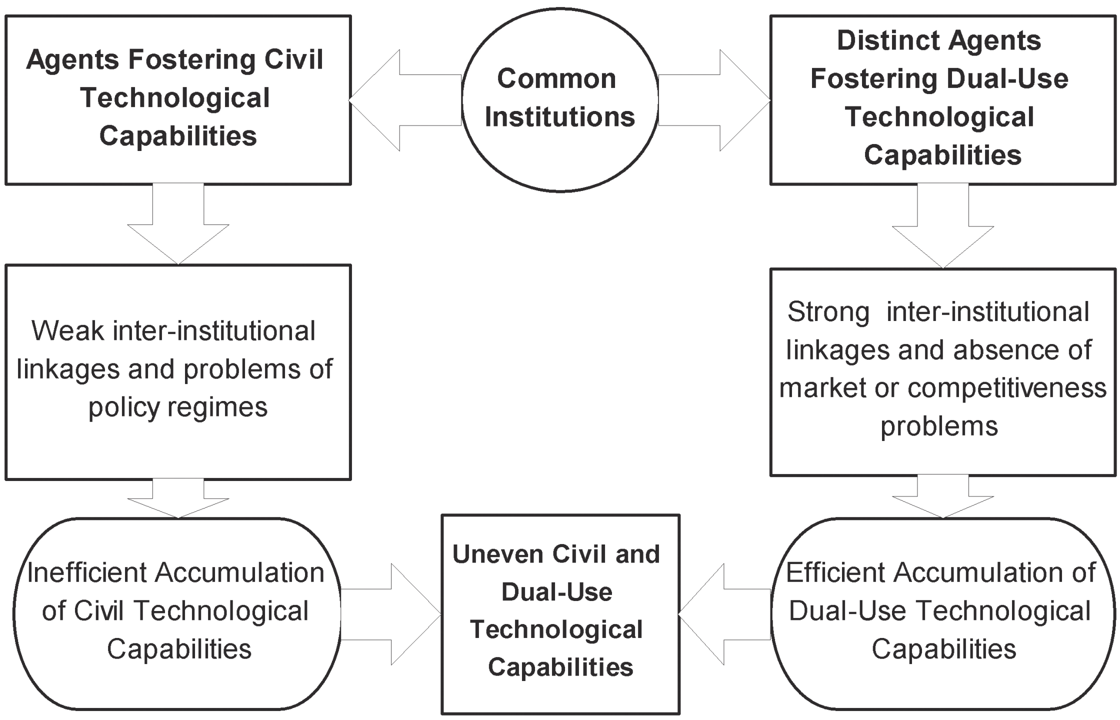
By the mid 1980s dissatisfaction with the performance of the economy started a shift towards an outward-looking national innovation system to achieve competitiveness and higher growth. This shift became clear when the industrial policy liberalisation was announced in 1991 that led to major changes in the areas such as industrial licensing, foreign investment, foreign technology agreements, public sector and Monopolies and Restrictive Trade Practices Act. The industrial policy - 1991 marked a clear shift from import regulating activity to export promotion activity. However, the impact of this liberalisation of policy regime is not fully clear. While foreign technology import and investment has increased in the 1990s, there appears to be a small decline in domestic R&D investment of firms, particularly in the private sector (Goldar and Renganathan, 1998; Kumar and Agarwal, 2000). A number of foreign companies have established manufacturing operations in India since liberalisation. One of the significant developments is the opening up of R&D centres by MNCs in India and forging of collaborative relationships with Indian S&T institutions. The impact and benefit of this may only be clear after some years. Another development is the outsourcing of operations by foreign companies to India, mainly in the service sector. This seems to be increasing as this helps foreign companies to cut cost and enhance their efficiency, because of high-skilled and highly qualified workforce available in abundance in India (Getty, 2003). The complexity and volume of outsourcing to India seems to be increasing and has already come under strong criticism by politicians and trade unions in the US, UK, and Germany (BBC News, 12 June 2003). In the era of 'knowledge economy' it is an important development, as skills are as much valuable as technology and products. India was more used to 'brain draining' (Indians seeking jobs abroad) than 'brain seeking' (foreign companies employing skills in India). Although one might dismiss this as attraction of 'cheap labour', this is not an insignificant development. However, it will be some time before the full implication of this development becomes clear.

In the area of export and competitiveness, progress appears to be slow in many industrial sectors may be because of gestation period required to shift from inward-looking to outward-looking system. However, the IT sector, which emerged in the 1980s and 1990s as a major sector has witnessed significant export growth, particularly in the area of software. There is a general perception that the availability of abundant skilled labour is the main reason for this. The answer is more complex than this. India missed the semiconductor revolution in the 1970s, due to protectionism and inter-departmental turf war. Compared to total world electronics production India's production was insignificant. For example, it was less that 0.5 per cent of the world production in 1982 (Commerce, 1983, p.1). Indian electronics industry was found "lagging far behind even the very small countries which joined the race much later" (Khandelwal, 1981, p. 10). India learned valuable lessons and was careful not to repeat the mistake in the 1980s when the computer/IT revolution started. Since early 1980s, that is, long before the major liberalisation in the 1990s, significant policy measures were taken to promote and expand the computer industry. The Computer Policy was announced in 1984 that removed capacity curbs, liberalised the licensing system and import duty to enable economies of scale and increase competitiveness (Commerce, 1984, p. 845). The Electronics Policy 1985 noted that "the software content of electronics is increasing and India is most appropriately placed to take advantage of this" (Bhojani, 1985, p. 807). The computer industry was predominantly left in the private sector and competitive environment was fostered. Soon, hundreds of firms in all sizes emerged. This subsequently appears to have established India as a leading player in the software market in the 1990s. By 1999-2000 India's software exports amounted to US$4.02 billion and it increased to US$ 6.3 billion in 2000-2001. India's success in this sector was mainly due to intensive R&D effort by the companies and the presence of strong basic research capability in the country (Government of India, 2002). The liberalisation of policy regimes in the 1990s has demonstrated the potential of Indian innovation system in achieving a higher rate of growth despite persistent weaknesses of Indian innovation system such as continuing problems in forging closer linkages between R&D institutions and firms.

V. 'DUALITY' IN INDIAN NATIONAL INNOVATION SYSTEM

Over the last five decades, India has accumulated a high level of technological capabilities in complex dual-use areas such as nuclear and space (Baskaran, 1998, 2000, 2001, and 2001a; Raj, 2000; Chengappa, 2000). Compared to most civil sectors, technology accumulation in complex dual-use areas appears to be more efficient and deeper. This presents an uneven technology accumulation in these two areas. This 'duality' (as illustrated by Figure 3) mainly occurred due to the differences in the agents that determine performance in the civil and complex dual-use technologies. For example, competence building in complex dual-use technologies is influenced by factors such as export control regimes, national security considerations and national prestige, which do not play major role in the case of most civil technologies (Pullinger, 1991; Navias, 1990; Nolan, 1989). In the face of stringent export controls, capability building in dual-use technologies demands not only the ability to adopt and improve foreign technologies (as in the case of most civil technologies), but also the ability to create new technologies and the ability to sustain the pace of technical change without any foreign input. Besides, compared to most civil technologies, competence building in dual-use technologies requires a high level of skills and co-ordination as well as a high level of R&D and industrial capacity. It requires mastering of manufacturing techniques involving special kinds of materials, alloys, chemicals, and micro-electronics that is not necessary in most civil technologies. Contrary to the perception that 'technology, like markets, has become accessible to any firm that makes the requisite investments' (Nelson, 1990, p. 76), dual use technologies are controlled by unilateral and multilateral export control regimes. Therefore, assumptions related to East Asian model such as importing technology, assimilation, and adaptation could be inappropriate in dual-use areas. Further, factors like profit motive, cost-effectiveness and cost-benefit do not play the same role in dual-use areas. As India has been investing heavily in dual-use areas, these factors appear to have created 'duality' in Indian national innovation system.

Figure 3: Duality in Indian National Innovation System



A study of firms that mainly operate in civil technology sector but also involved in the space programme has shown different experiences in these two areas and highlighted the 'duality' in Indian national innovation system (Baskaran, 1998, 2000). It showed the Indian Space Research Organisation (ISRO) has forged strong linkages between space centres, public R&D institutions and universities to execute the space programme. It also showed the important role played by the basic research in space technology accumulation unlike in the civil areas. It is clear that while the Indian system of innovation in complex dual-use followed the conventional Western model where basic research plays an important role in creating a new technology, in contrast, in civil technologies it followed the East Asian model where imported technology leads to new capabilities (Hobday, 1995; Baskaran, 2000).

VI. PERFORMANCE OF INDIAN SYSTEM OF INNOVATION

From the beginning, India put greater emphasis on 'big-science' programmes such as nuclear and space programme and they were allocated large resources. This affected the development of S&T infrastructure in other areas such as agriculture and medicine until the late 1960s and also the funding of academic research in the universities (Krishna, 2001, pp.6-7). Further, the promotion of 'big-science' programmes has led to 'lopsided' or 'duality' in Indian innovation system. That is, compared to most civil sectors, India has accumulated a high level of technological capabilities in complex dual-use areas and India's system of innovation proved to be more efficient in these areas (Baskaran, 1998, 2000, 2001, 20001a; Raj, 2000; Chengappa, 2000).

India's innovation system often faced criticism because of its inefficiency that led to low rate of growth, its poor export performance, and relatively low quality of manufactured goods. These criticisms, although valid, either ignored or deliberately failed to take into account the context of the evolution of national innovation system in India. Particularly in the first phase, the principal objective of India's economic and S&T policy regimes was creating indigenous capabilities in the industry to meet as much domestic demands as possible, and there by reducing or avoiding undue foreign dependence. Although ritual mentions were made in policy declarations about exporting, it was not the main driver of Indian innovation system in the first phase unlike the case of South Korea or Taiwan. Indian firms failed to export not because they were incapable, but because they "prefer to exploit local markets where they have factor cost and marketing advantages" (Eisemon, 1984, p.272). Despite major flaws, there were significant achievements during the first phase of Indian national innovation systems. These included: (i) creation of S&T infrastructure and the expansion of higher education with great emphasis on basic research; (ii) development of indigenous capability to produce a range of goods which even today many developed countries are not capable of; (iii) implementation of the Green Revolution to achieve self-sufficiency in food grains; and (iv) creation of the scientific and industrial innovative potential to compete at international market.

Considering that India fought three major wars and faced severe droughts and chronic foreign exchange constraints between 1950s and 1980s, India's investment in S&T infrastructure and R&D expenditure were significant. Its R&D investment ranged between 0.8-0.9 per cent of GNP that is comparable not only to developing countries like Brazil and China but also to some developed countries (see Tables 1 and 2). This created a vast network of basic S&T infrastructure. The number of research institutions at the time of independence in 1947 was 11. This increased to 63 by 1960 and 555 by 1980. The R&D units within firms were 13 in 1950, which increased to 400 in 1975 and 750 in 1981-82 (Subrahmanian, 1990, p. 208; Eisemon, 1984, p.272). By 1980 the number of science and engineering graduates increased to 2.65 per thousand of population from 1.04 in 1960. There were 697, 600 scientists and engineers and about 7 per cent of them were engaged in R&D activities. The number of scientists, engineers and technicians (SET) per 1000 population in India is also significant (see Tables 3 and 4).

An efficient innovation system is where technological accumulation and progress is also accompanied by higher growth performance of the industrial sector. During Phase I, the industry has witnessed significant growth, although "the overall growth rate remained much below the plan targets and also below the achievements of several newly industrialising countries such as South Korea and Brazil" (Subrahmanian, 1990, p. 205). Initial high growth rate gave way to stagnation since mid-1960s. However, this changed since mid-1980s when India started liberalising its industrial and technology policy regimes. Since then, the industrial growth ranged between 6.5 to 9 per cent

(Government of India, 2001, p. 303). The relative inefficient performance in Phase I appears to be largely because of rigid policy regimes.

The liberalisation in Phase II aimed to accelerate investment, growth, and employment appears to have produced mixed results. On the positive side, GDP growth was higher in 1990s than in previous decades. The foreign currency reserves also increased from US$1 billion in 1991 to over US$ 45 billion in 2002. The debt service ratio was brought down from 35.3 per cent of current receipts in 1990-91 to 16.3 per cent in 2000-01. The external debt-GDP ratio has improved from 38.7 per cent in 1992 to 22.3 per cent in 2001 (see Table 5). The literacy level has improved from 52 per cent in 1991 to 65 per cent in 2001 (Government of India, 2002). However, after witnessing a high level growth in the initial period of liberalisation, the GDP growth has slowed down in the latter part of 1990s. As shown by Table 6, this trend has been repeated in the industrial sector growth (Government of India, 2001, p. 303). Despite some inconsistent performances, Indian system of innovation is refining and it is likely to perform with greater efficiency with increasing reforms to policy regimes. However, liberalisation of policy regimes may not be enough to realise the full potential of Indian system of innovation. For this, fundamental changes to the institutions and research cultural may be needed.

TABLE 1: COMPARISON OF MAJOR ECONOMIC INDICATORS AND R&D EXPENDITURE AS PERCENTAGE OF GNP BETWEEN INDIA AND SELECTED COUNTRIES (WORLD-WIDE)

Country	Year*	R&D Expenditure (% of GNP)	Gross National Product (GNP) in US$ -billions (1999)	Per Capita GNP in US$ (1999)	GNP-Average Annual % Growth 1998-99	GDP—Average Annual % Growth 1990-99
India	1998	0.82	442.2	480	6.9	6.1
Argentina	2000	0.45	277.9	7 600	- 2.9	4.9
Brazil	2000	0.77	742.8	4 420	- 2.0	2.9
Canada	2000	1.84	591.4	19 320	3.8	2.3
China	2000	1.00	980.2	780	7.2	10.7
Egypt	2000	0.19	87.5	1 400	5.7	4.4
France	2000	2.15	1 427.2	23 480	2.4	1.7
Germany	2000	2.48	2 079.2	25 350	1.2	1.5
Israel	1999	3.62	---	---	--	5.1
Japan	2000	2.98	4 078.9	32 230	1.0	1.4
Madagascar	1995	0.18	3.7	250	5.5	1.7
Nigeria	1987	0.09	37.9	310	3.0	2.4
Republic of Korea	2000	2.68	397.9	8 490	11.0	5.7
Russian Federation	2000	1.00	332.5	2 270	1.3	- 6.1
Senegal	1997	1.40	4.7	510	5.1	3.2
Singapore	2000	1.88	95.4	29 610	5.6	8.0
South Africa	1993	0.70	133.2	3 160	0.8	1.9
Spain	2000	0.94	551.6	14 000	3.7	2.2
Sweden	1999	3.80	221.8	25 040	3.9	1.5
Tunisia	2000	0.45	19.9	2 100	6.2	4.6
Uganda	1999	0.75	6.8	320	7.7	7.2
UK	1999	1.87	1 338.1	22 640	1.7	2.2
USA	2000	2.69	8 351	30 600	4.1	3.4

SOURCE: UNESCO, STATISTICAL YEAR BOOK 1999 AND SCIENCE AND TECHNOLOGY: SELECTED R&D INDICATORS (1996-2000), NOVEMBER 2002; WORLD BANK, WORLD DEVELOPMENT REPORT 2000-2001
* YEAR RELATES TO R&D EXPENDITURE (% OF GNP) ONLY

TABLE 2: COMPARISON OF MAJOR ECONOMIC INDICATORS AND R&D EXPENDITURE AS PERCENTAGE OF GNP BETWEEN INDIA AND SELECTED AFRICAN COUNTRIES

Country	Year*	R&D Expenditure (% of GNP)	Gross National Product (GNP) in US$ -billions (1999)	Per Capita GNP in US$ (1999)	GNP–Average Annual % Growth 1998-99	GDP—Average Annual % Growth 1990-99
India	1998	0.82	442.2	480	6.9	6.1
Benin	1989	---	2.3	380	5.1	4.7
Burkina Faso	1997	0.19	2.6	240	5.2	3.8
Burundi	1989	0.31	0.8	120	- 0.5	- 2.9
Central African Rep.	1984	0.25	1.0	290	3.7	1.8
Congo Rep.	1984	0.01	1.9	670	7.7	0.9
Egypt	2000	0.19	87.5	1 400	5.7	4.4
Madagascar	1995	0.18	3.7	250	5.5	1.7
Mauritius	1997	0.28	---	---	---	---
Nigeria	1987	0.09	37.9	310	3.0	2.4
Rwanda	1995	0.04	2.1	250	7.5	- 1.5
Senegal	1997	1.40	4.7	510	5.1	3.2
South Africa	1993	0.70	133.2	3 160	0.8	1.9
Togo	1994	0.48	1.5	320	2.1	2.5
Tunisia	2000	0.45	19.9	2 100	6.2	4.6
Uganda	1999	0.75	6.8	320	7.7	7.2

SOURCE: UNESCO, STATISTICAL YEAR BOOK 1999 AND SCIENCE AND TECHNOLOGY: SELECTED R&D INDICATORS (1996-2000), NOVEMBER 2002; WORLD BANK, WORLD DEVELOPMENT REPORT 2000-2001
* YEAR RELATES TO R&D EXPENDITURE (% OF GNP) ONLY

TABLE 3: COMPARISON OF NUMBER OF SCIENTISTS, ENGINEERS, AND TECHNICIANS (SET) – BETWEEN INDIA AND SELECTED COUNTRIES (WORLD-WIDE)

Country	Year*	All R&D Personnel	Research Persons	Technicians	Support Staff	Year**	Research Persons / million	Technicians / million
India	1996	357 172	149 326	108 817	99 029	1994	149	108
Argentina	2000	37 515	26 420	5 707	5 228	1995	660	147
Brazil	2000	78 565	55 103	21 914	1 548	1995	168	59
Canada	1998	139 570	90 200	31 380	19 560	1993	2 648	1 070
China	2000	922 131	695 062	---	---	1995	347	200
Egypt	1991	102 296	26 419	19 607	56 274	1991	459	341
France	2000	314 452	160 424	---	---	1994	2 583	2 873
Germany	1999	480 415	255 260	110 364	114 415	1993	2 843	1 472
Israel	1997	13 110	9 161	3 023	926	1984	4 828	1 033
Japan	1999	919 132	658 910	84 527	175 695	1994	6 293	827
Madagascar	2000	985	240	730	15	1994	12	37
Nigeria	1984	18 345	1650	9 696	6 999	1987	15	76
Republic of Korea	1999	137 874	100 210	26 160	11 504	1994	2 637	318
Russian Federation	1999	989 291	497 030	80 498	411 76	1997	3 587	600
Senegal	1996	78	19	29	30	1996	3	4
Singapore	2000	19 365	16 633	---	---	1995	2 318	301
South Africa	1993	60 464	37 192	11 343	11 929	1993	1 031	315
Spain	1999	102 237	61 568	40 670	---	1994	1 211	343
Sweden	1999	66 674	39 921	---	---	1993	3 706	3 166
Tunisia	1999	5 363	3 149	292	1 922	1997	125	57
Uganda	2000	1 187	549	330	308	1997	21	14
UK	1998	---	157 662	---	---	1993	2 413	1 017
USA	1997	---	1 114 100	---	---	1993	3 676	---

SOURCE: UNESCO, STATISTICAL YEAR BOOK 1999 AND SCIENCE AND TECHNOLOGY: PERSONNEL ENGAGED IN R&D (1996-2000), NOVEMBER 2002.
* YEAR RELATES TO ALL R&D PERSONNEL, RESEARCHERS, TECHNICIANS AND SUPPORT STAFF COLUMNS ONLY.
** YEAR RELATES TO RESEARCH PERSONS / MILLION AND TECHNICIANS / MILLION

TABLE 4: COMPARISON OF NUMBER OF SCIENTISTS, ENGINEERS, AND TECHNICIANS (SET) – BETWEEN INDIA AND SELECTED COUNTRIES (AFRICA)

Country	Year*	All R&D Personnel	Research Persons	Technicians	Support Staff	Year**	Research Persons / million	Technicians / million
India	1996	357 172	149 326	108 817	99 029	1994	149	108
Benin	1989	2 687	794	242	1 651	1989	176	54
Burkina Faso	1997	780	176	165	439	1997	17	16
Burundi	1989	814	170	168	476	1989	33	32
Central African Rep.	1996	19 500	---	---	---	1990	56	32
Congo Rep.	2000	217	101	111	3	1984	462	789
Egypt	1991	102 296	26 419	19 607	56 274	1991	459	341
Madagascar	2000	985	240	730	15	1994	12	37
Mauritius	1992	1 162	389	170	603	1992	361	158
Nigeria	1984	18 345	1650	9 696	6 999	1987	15	76
Rwanda	1995	315	181	40	94	1995	35	8
Senegal	1996	78	19	29	30	1996	3	4
South Africa	1993	60 464	37 192	11 343	11 929	1993	1 031	315
Togo	1994	1 473	387	249	837	1994	98	63
Tunisia	1999	5 363	3 149	292	1 922	1997	125	57
Uganda	2000	1 187	549	330	308	1997	21	14

SOURCE: UNESCO, STATISTICAL YEAR BOOK 1999 AND SCIENCE AND TECHNOLOGY: PERSONNEL ENGAGED IN R&D (1996-2000), NOVEMBER 2002.
* YEAR RELATES TO ALL R&D PERSONNEL, RESEARCHERS, TECHNICIANS AND SUPPORT STAFF COLUMNS ONLY.
** YEAR RELATES TO RESEARCH PERSONS / MILLION AND TECHNICIANS / MILLION

TABLE 5: INDIA – TRENDS OF MAJOR MACROECONOMIC INDICATORS (1990-91– 2000-01)

Country	1990-91	1991-92	1998-99	1999-2000	2000-01
1. Growth Rate (%)					
GDP at constant factor cost	5.6	1.3	6.5	6.1*	4.0+
Industrial Production	8.2	0.6	4.1	6.7	5
Exports (BOP in US$)	9	-1.1	-3.9	9.5	19.6
Imports (BOP in US$)	14.4	-24.5	-7.1	16.5	7
2. As % of GDP at current					
market prices					
Total foreign investment net (BOP)	0.03	0.05	0.6	1.2	1
Foreign direct investment (FDI) net	0.03	0.05	0.6	0.5	0.4
3. Foreign Exchange Reserves (US$ billion)	5.8	9.2	32.5	38	42.3
4. Debt Indicators					
External Debt/GDP ratio (%)	28.7	38.7	23.6	22.2	22.3
Debt service ratio (%)	35.3	30.2	18	16.2	17.1

SOURCE: GOVERNMENT OF INDIA (MINISTRY OF FINANCE), ECONOMIC SURVEY 2001-2002.
NOTES:* PROVISIONAL + QUICK ESTIMATE

TABLE 6: INDUSTRIAL GROWTH IN INDIA BETWEEN 1960 AND 2000

Year	Index	Growth rate	Year	Index	Growth rate
Base: 1970 = 100			Base: 1980-81 = 100		
1960-61	55.8	---	1985-86	142.1	8.7
1963-64	72.3	9.3	1986-87	155.1	9.1
1964-65	78.6	8.8	1987-88	166.4	7.3
1965-66	84.8	5.3	1988-89	180.9	8.7
1966-67	83.3	0.6	1989-90	196.4	8.6
1967-68	82.8	1.2	1990-91	212.6	8.3
1968-69	89.9	6.7	1991-92	213.9	0.6
1969-70	96.8	7.6	1992-93	218.9	2.3
1970-71	100.7	4.1	1993-94	232.0	6.0
1971-72	106.4	5.6			
1972-73	110.6	3.9	Base: 1993-94 = 100		
1973-74	111.5	0.8	1994-95	109.1	9.1
1974-75	115.1	3.2	1995-96	123.3	13.0
1975-76	122.8	6.7	1996-97	130.8	6.1
1976-77	134.4	9.5	1997-98	139.5	6.7
1977-78	140.0	4.2	1998-99	145.2	4.1
1978-79	150.7	7.6	1999-2000	154.9	6.7
1979-80	148.2	- 1.6	2000-2001	162.7	5.0
1980-81	154.1	4.0			
1981-82	167.3	8.6			
1982-83	174.3	4.1			
1983-84	184.9	6.1			
1984-85	197.4	6.8			

SOURCE: GOVERNMENT OF INDIA, HANDBOOK OF INDUSTRIAL POLICY AND STATISTICS, 2001, P.303.

TABLE 7: R&D EXPENDITURE AND ITS SHARE IN WORD TOTAL BY CONTINENTS (1980– 1990)

R&D Expenditure (US$ billion)				As % Share in World Total R&D Expenditure		
Continent	1980	1985	1990	1980	1985	1990
Africa	1.1	0.9	1.1	0.5	0.3	0.2
America	70.4	118.9	196.6	33.8	43.7	43.4
Asia	31.7	47.2	91.2	15.2	17.4	20.2
Europe	70.7	65.6	105.0	33.9	24.1	23.2
Oceania	2.2	2.1	3.0	1.1	0.8	0.7
Former Soviet Union	32.3	37.2	55.7	15.5	13.7	12.3
World Total	208.4	271.9	452.6	100	100	100

SOURCE: GOVERNMENT OF INDIA, HANDBOOK OF INDUSTRIAL POLICY AND STATISTICS, 2001, P. 497

V. SHARING INDIA'S EXPERIENCE WITH AFRICAN SYSTEM OF INNOVATION

Hardly any research on the African system of innovation has been undertaken to date. There is, however, a need to elaborate the wider African as well as specific state, region and sector specific systems of innovations in Africa. The broad features that can describe an African system of innovation are stated below.

- The specific aspect that needs changing to date is that the elements in the system that enter to constitute a specifically African NSI - both the technology and institutional dimensions - are mainly externally driven rather than having been endogenously propelled based on the interactions of national social-economic arrangements and the different knowledge systems, which exist in African societies. While India has mixed planning and the market to establish a largely self-reliant system of innovation, knowledge and technology to Africa has been diffused from externally. India has the innovation system (lopsided and dualistic it may be) to internalise external knowledge into its system of production.

- The external dimension remains critical in the innovation, learning, and accumulation of knowledge, the building of competencies and capabilities in organisation, product, process, techniques, market and management in the continent. India has managed to internalise these into its national context. It has developed significant internal capabilities and developed firms' ability to choose technology imports successfully that helped reduce undue dependence on imports.

- Africa's research environment including its science and technology system has been dominated by foreign sponsorship.

The R & D expenditure as a proportion of the gross national product (GNP) for the continent as a whole was a mere 0.28 per cent in 1980, while Asia spent 1.40 per cent of its GNP on R & D, and North America a 2.23 per cent. By 1990 the situation has worsened in Africa by R & D dropping to 0.25 per cent while in Asia it had increased to 2.05 per cent and in North America to 3.16 per cent. The structural adjustment impact has not changed the science and technology system in Africa (Inos, 1995). Overall, the share of Africa in the world R&D investment has been the least among various regions and continents (see Table 7). On the whole countries in Africa spend nearly a tenth of the percentage of GDP that industrialised countries expend on R & D.

India has created local R & D and has invested in science and engineering to create both the human resources and physical resources internally.

- Africa has not put in place mechanisms for intellectual property and patents for inventions and innovations despite the setting up of two regional organisations (Organisation African de La Propriety Intellectual (OAPI) based at Yaounde, Cameroon set up as early as 1962 and the African Regional Intellectual Property Organisation (ARIPO) based in Harare, Zimbabwe (established in 1976). The system of intellectual property continues to protect foreign patents rather than stimulate and furnish incentives to African inventors and innovators. The AU may make new efforts, but the problem still exists. India is active in WTO negotiations to create a national intellectual property regime that protects not only Indian inventors and innovators but also those from the developing world. Some countries such as South Africa in Africa play also a significant role like India.

• Many African Governments have established science and technology policy machinery assisted by UNESCO and foreign consultants, but the utilisation of science and technology for bringing about a structural transformation of economy and society remains to be undertaken. State support to R & D has yet to grow and supplant the disproportionate donor funding it is projected to receive for the foreseeable future. India relies on a national science and technology system and funds its own science largely from its own resources.

• The private sector source's contribution to innovations is either from the in- house R & D departments of major multinational companies and /or from purchases in the form of capital and turnkey projects. The African centred R & D development and the link with production needs yet to be developed and increased. India's private sector is very active in innovative activity.

• While there is no problem in learning from outside the weakness of linkages between the formal and informal institutions, private and public institutions, and the indigenous and exogenous technological innovations dissipates the external input.

• It has been claimed that the market, state, production and business and learning systems do not often work in concert. Institutions, structures of production, and infrastructure have weak techno-economic networks. Inter-African communication linkages are still to be forged. India also has a lopsided and uneven national system of innovation largely because of inefficient inter-institutional linkages and policy regimes.

• The science and technology system in African countries is mainly donor driven and much R & D requires donor input. For example in Senegal, between 30-40 per cent of scientists are French nationals (Tiffin and Osotimehin, 1992, p. 44). This unduly injects donor influenced terms of references, priorities and donor preferences into the African system of innovation more than any region in the world. About 80-90 per cent of the recurrent R & D budget is said to be devoted to personnel emoluments (Tiffin and Osotimehin, 1992, p. 44). Local researchers are severely disadvantaged in research agenda setting with respect to donors. Pattern of assistance is said to be skewed to favour the learning of expatriate personnel more than domestic researchers.

• The scientific and technological human resources in Africa are said to be below the critical threshold necessary to provide effective and innovative leadership in R & D. India has trained skill labour which it is exporting to even the advanced countries.

• Many African researchers are said to be outside and those inside work for external actors and agencies. Indians work for both national and outside firms.

• It is claimed that there is no African research university comparable to the level and distinction of the major European and American centres of learning and research perhaps except a few universities in South Africa. India has a relatively functioning higher education system.

• The policy environment in facilitating linkages and techno-economic networks is said to be largely unreliable. The domains of state, market, civil society remain weakly linked where the actors and activities emerging from them seem to sustain weak learning and innovation techno-economic networks. The Indian system has a stronger techno-economic networks relative to Africa, though it may still not be coherent enough in relation to the developed Western economies.

VI. CONCLUSIONS

The major lesson that African states can learn from India is the fact that India has established a national system of innovation capable of internalising knowledge from the outside. Africa is still not in a position to develop a strong system of innovation. It relies far too much on outside knowledge and technology and medium of transaction. This has to change. It can change if Africans build capacity by strengthening the African Union.

Most African economies rely on mineral and mono-crop export. They lack a strong industrial structure. India has evolved an industrial sector that can compete internationally.

Many African countries rely for about 80 per cent of their export earnings on primary commodities, and their share of manufactured exports continue to be very low compared with India. India's industrial growth was positively growing not fluctuating as in African countries. This is because India has successfully diversified its economic structure.

India has in Bangalore its own Silicon Valley, whilst Africa's infrastructure-electricity and telecommunications network have been growing very slowly by international standards. In Sub-Saharan Africa except for South Africa, the average main telephone lines per 100 people is only 0.5 (9.5 in South Africa). African countries are universally lacking in locally manufactured computer hardware and in-local-language software, so the use of computer and Internet is not popular in the Continent. Factory automation and computerisation are uncommon in African industries, and this is preventing the industries from becoming internationally competitive. Most African countries rely on the importation of IT technology and products. So far, more than half of African countries have some form of e-mail service and a gateway to the Internet. The pattern of dependence persists: For example:

" At present, e-mail sent from one Tanzanian computer to another must often transit Western Europe or the US before being redirected, greatly increasing costs for Tanzanian service providers and therefore customers" (Africa Business, August/ September 2003, p.43).

The main lesson that Africa must learn from India t is to create a unification-nation within which a system of innovation can be embedded regardless of the imperfection of this system.

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