# Technology improvement after independence

This paper reviews the science and technology policies of India and how these have fashioned Indian’s technology capability over the years. It shows that while India has achieved enormous strides In the area of science, technology and Innovation, inappropriate policies In the past have hampered the development of an effective national innovation system. The paper concludes by drawing lessons for the development of an EX.-wide science and technology policy. 4 1. Introduction 1. 1 The Changing Scientific and Technological Landscape In the asses and asses, the United States was internationally pre-eminent in science and technology.

The only entry comparable to the US In terms of per capita innovative output during this and achievement remained the exclusive preserve of a few advanced industrialized countries. In the last 30 years or so, however, the economic landscape has changed considerably and indeed continues to change with amazing rapidity. A situation of strategic economic parity has come to exist in the triad regions of North America, Western Europe and the Pacific Rim (including China). Increasing globalization has meant that several more nations have become important players on the world economic stage and the rules of the game have subsequently changed.

To some extent, it is no longer easy for any one player to dictate the rules of the game – to determine what is right or wrong, or what is or what ought to be. In the area of science, technology and innovation, the supremacy of the United States and the few other monopoly powers has become seriously challenged and partly eroded. Several developments have materialized. Firstly, there has been increased competition from fast followers, which has subjected advanced nations to competition via imitation by firms in hitherto

less innovative countries. Secondly, there has been a more rapid diffusion of intellectual capital.

This has been aided by the revolution in communications technology, which has rendered the notion of space and time virtually irrelevant. The result of this is that the advantage provided by a given amount of innovation decreases rapidly with increased diffusion of intellectual capital. Thirdly, competition for investments by multinational enterprises (Ones) mean that these companies increasingly need to locate investments wherever circumstances offer the greatest opportunity, including Research and Development (R) activities. Lastly, there has been a steady, albeit gradual, emergence of more actions that are innovators.

These have consciously committed themselves to the expansion of their innovative capacity with the result that the historically small set of highly-innovative advanced countries has expanded. In addition, the Scandinavian countries, the newly industrialist's countries of South East Asia, China and India are also beginning to make the transition from imitator to innovator. 5 This paper charts the various phases of science, technology and innovation (SST') policies of India and their impact on the nation's technology capability, and considers future policy prospects and development implications.

With a population of over 1000 million, India is the world's second largest country after China and the largest democracy. In terms of land area, it is the seventh biggest country in the world. With a GAP of about $Bonn, India is the world's eleventh richest nation but in purchasing power parity terms, it is fourth after, the US, China and Japan. The Indian economy has a strong

element of duality. It is one of the most industrialized countries in the world, with remarkable achievements in indigenous technology, oceanography, deep- sea oil drilling, nuclear power, space and satellite communications and armaments manufacture.

It is also a successful agricultural country. Three-quarters of the population owe their livelihoods to the sector, which coupled with fisheries and arrangement of the paper is as follows. After this introduction, section 2 charts trends in Indian’s science and technology (S) policy since independence in 1947, while section 3 considers the impact of recent policy. Section 4 looks at Indian’s stance in relation to the multilateral system (the WTFO), especially with regard to the TRIPS agreement while section 5 looks at the future stance of policy and its implications for Indian’s development.

The last section concludes the paper and draws lessons for EX. policy. 1. 2 The Rationale for Science and Technology Policy In a isolating world economy the comparative advantage based on endowments of basic factors of production, like natural resources, has become less important. An abundance of traditional factors of production – raw materials, energy, and unskilled labor – is not enough to guarantee long-term success. Rather, it is continuous innovation and improvement in productivity that are crucial. In this wise, national competitive advantage is not inherited – it has to be created.

And as most of the innovative activity takes place in private enterprises, a country’s international competitiveness is a question of how competitive its firms are, how its industries perform in world markets, how its institutions

are organizes and how successfully its science, technology and industrial policies affect the performance of firms and industries. 6 While it is the private sector that constitutes the engine of innovation, national policies create environments that can encourage or constrain the ability of firms to innovate. The more innovative firms are, the more they are profitable and the more alee-added they create in a nation.

It is, therefore, vital for countries to put in place policies to create an effective and efficient national innovation system (EN’S). Four conditions need to be met for building an effective national innovation system. These are a) strong and competitive pressures on domestic firms; b) the presence of high quality human capital; c) wallpapered links between industry, institutions and academia; and d) openness and access to foreign technologies. These determinants of an INS indicate that innovation involves far more than science and technology.

It Anton be denied, however, that a forward-looking S policy can be developed to foster an appropriate mix of these determinants. Indeed, the first step towards, and the necessary pre-requisite to, any good INS is an effective S policy. In recognition of this, all advanced and industrialist’s countries consciously foster an S&T policy. The pressures of international competition have made both knowledge creation and exploitation vital for business success. As a result, the internationalization of R&D has increasing relevance for strategic management of companies and the strengthening f national innovation systems.

The globalization of R&D is establishing deep roots for several reasons. Firstly, changing geopolitical infrastructures are creating new opportunities for synergistic R&D activities across national frontiers. Secondly, rapidly Thirdly, increasing complexities of technological systems are making it imperative to generate and implement knowledge in emerging fields quickly and collaboratively. Fourthly, the need for brainpower with an ever-increasing sophistication is being met by identifying and employing people with the appropriate skills at appropriate locations wherever they may be.

International R&D strategy is thus emerging to meet these challenges. To this end, firms in developed countries and increasingly in some developing countries are being driven to take advantage of world-wide science and technology resources. These factors have spurred the growth of science and technology developments in those nations, which have conducive environments. Israel, Taiwan, Singapore, South Korea and, to a lesser extent, Ireland, have made substantial progress in upgrading their innovative capacity and, as a result, have become beneficiaries of foreign investments in science and technology ventures.

Although countries such as India, China and Malaysia, have increased investments in areas related to science, technology and innovation at 7 modest levels, there is little doubt that some of these, especially China and India, are potential scientific powerhouses. 2. Trends in SIT Developments in India 2. 1 Market-oriented Reforms in India India is experiencing an economic renaissance. Economic reforms introduced by the Raw administration in 1991 in the wake of serious macroeconomic difficulties have taken root and a major restructuring of the economy, albeit slow, is continuing.

With a population of over 1000 million including n estimated middle class of about 250 million people, Indian’s domestic market potential among developing countries is second only to China’s, and close to all countries of the Association of South East Asian Nations (SEAN) combined. After independence in 1947, the early leaders of India committed themselves to a policy of industrialization based on self-reliance. For almost four decades after independence, India pursued an isolationist and import-substitution strategy across all its sectors.

This produced large and inefficient enterprises, many of them state-owned and unaccustomed to competition. The result was an economic growth typically of 3. 5% per year (equivalent to 1% growth per capita) – what had become known as the “ Hindu rate of growth”. From the early asses, a growing consensus emerged in favor of economic liberation’s. Powerful vested interests, including leaders of protected industry, unions and politicians, ensured that early initiatives were limited to little more than incentives to exporters, minor industrial deregulation and some simplification of the tax regime.

The modest changes led to an average growth of 5. 3% a year, which was not only much higher than that of the decades before but was also better than the growth performance of all developing countries put together. The high degree of protection from foreign competition and the basic problem of policy to achieve a depreciation of the real effective exchange rate was pursued with a view to boosting exports. The fiscal policies of the Central Government also became expansionary in the asses to support growing

expenditure on account of sharply rising interest payments and expenditures on defense and subsidies.

The gross fiscal deficit of Central Government 8 increased from 6. 2% in 1980/81 to 8. 4% by 1990/91. The rate of inflation of 8. % was stable but the current account deficit rose from 2. 5% in 1985/86 to 3. 3% in 1990/91. The Gulf War in 1990 precipitated a balance of payment crisis and this was not helped by the political instability at the beginning of the asses, which combined to cause a collapse of international confidence in the ability of the government to manage the economy. This caused external commercial loans and inflow of non- resident Indian (NOR) capital to dry up.

The stage was set for a possible international default. Despite emergency borrowing from the International Monetary Fund (MIFF), he level of exchange reserves dropped to Just over $1 billion, barely sufficient to finance imports for a fortnight. The rate of inflation accelerated to double digits (10. 30%) from 7. 4% a year earlier. By August 1990, inflation had shot upwards to 17%. It was within this background that the newly elected Government of Mr. Raw launched a programmer of ambitious economic reforms in July 1991.

The reforms were designed within an overall dual strategy whereby fiscal adjustment aims to achieve macroeconomic stability were combined with structural reforms in industrial, trade ND financial policies to strengthen growth capacity and international competitiveness of Indian industry. The main tenets of the reforms included: the opening up of more sectors to private investment and participation – power, steel, oil refining and exploration, road construction, air transport, telecommunications, ports,

mining, pharmaceuticals and financial services. Encouragement of FAD with majority equity, except in a few strategic sectors, and portfolio investment. Red tape was significantly reduced. De-licensing of most industries to encourage competition. Domestic investment in defense-related items was permitted. Read liberation’s. Some import quotas were converted into tariffs, and the tariff system was simplified to reduce the number of bands and achieve a reduction in overall rates. As of 2001 (April), quantitative restrictions (Sirs) on imports have been removed. He taking out of state control some aspects of business decision-making such as the location of new enterprise and technology transfer. The exchange regime was liberalized, with the devaluation of the rupee by 22% against the US dollar in two installments in July 1991. A market-determined exchange 9 (the rupee is, however, not yet fully convertible on the capital account). Reform of capital markets. Private mutual funds, country funds and foreign institutional investors (Ells) were all made active investors.

Since 1991, the reform agenda has been progressed at every annual budget to bring the Indian economy into closer integration with the rest of the world. 2. 2 Trends in Indian’s Science and Technology Policy It has long been recognized that investment in science and technology makes substantial contribution to economic growth in terms of higher growth rates of an economy’s total factor productivity (Abortive, 1956, Dimension 1962 and Slow, 1957, among others). In addition to direct returns, huge (positive) externalities have also been found to be associated with it (Abortive, 1989).

Taking cognizance of the importance of technology’s role in development, advanced countries nurture continuing development of science and

technology and most developing countries adopt R policies in the early phases of their development. Science and Technology policy constitutes an integral part of a nation’s overall industrial policy (Barber and White, 1987). While the former shapes the pace and direction of technology development, the latter determines the nature f demand. This section reviews the evolution of Science and Technology policy in India since independence.

Science and Technology policy of any nation is carved within the background of overall industrial policy. If anything, S&T policy is supposed not only to give meaning to, but more importantly, to ensure achievement of the goals of industrial policy. It is therefore the thrust and direction of industrial policy that determines the tenets of any S&T policy, although it must be said that R&D may lead to results that may also change the course of industrial policy. Even so, S&T policy as almost always been driven by the goals of industrial development policy.

This section therefore describes the development strategy adopted by the government in the various phases of development and analyses the accompanying S&T policy. Two strands of S&T policy have existed – policies related to technology transfer from abroad through formal modes such as FAD, technology licensing and capital goods imports and domestic technology generation policies. 10 Having realized that the pursuit of tartaric economic policies in much of the absentmindedness period to 1990 was a mistake, India undertook sweeping reforms s a way of speeding economic growth and achieving faster integration into the world economy.

Part of these reforms has been the re-enactment of a science and technology policy more suited to the achievement of the goals of building a prosperous nation. The Industrial Policy Statement of 1991 had, among its objectives, the aim of " injecting the desired level of technological dynamism into Indian Industry' and " the development of indigenous competence for the efficient competitive pressure will induce our industry to invest much more in research and development than they have been doing in the past".

The intention was to create a national innovation system (EN'S) that was in sharp contrast to that prevailing prior to the July 1991. The national innovation system of a country is the set of institutions, policies and organizations and the interactions between them that determine the level of innovation arising from that country. While the increase in globalization has resulted in some dilution of the importance of the boundaries of the nation-state from an economic perspective, the INS continues to be an important determinant of a nation's economic performance. After independence in August 1947, the Indian

Government, under Charlatan Nehru set itself the task of socio-economic transformation of the country through a process of central planning. Science was given considerable importance in the development " Plans", as its significance in national development was recognized. Nehru firm belief that science and technology could play a major role in bringing both material and cultural benefit to the people of India may be summed up in a statement he made prior to independence and in the preamble of the very first S policy document prepared in 1958 under his guidance. " And I hope with Lord Rutherford that in the days to come,

India will again become the home of science, not only as a form of intellectual activity, but also as a means of furthering the progress of her people" Charlatan Nehru, 26 December 1937. " The key to national prosperity, apart from the spirit of the people, lies in the modern age, in the effective combination of three factors, technology, raw materials and capital, of which the first is perhaps the most important, since the creation and adoption of new scientific techniques can, in fact, make up for a deficiency in natural resources and 11 reduce the demand on capital.

But technology can only grow out of the study of science and its application". PR 1958. From independence in 1947 to date, India has had three distinct stances of industrial policy and, in consequence, three phases of commensurate science and technology policy. Gradual (2001) delineates these as (a) the Initial Growth Phase (1947-68), (b) the Restrictive Phase (1969-1980) and (c) the Liberalized Phase (1980-1990 and 1991 to date). The Initial Growth Phase The genesis of Indian's industrial policies was the Industrial Policy Resolution (PR), the work for which was started in 1948 and passed in 1958.

Under this policy, India reused a policy of import-substitution and placed emphasis on basic and heavy industries. A faster growth rate in the productive capacity of capital goods industries was seen as vital to raising savings and investment rates, diversifying the industrial sector and promoting manufactured exports. Given the negligible R&D base at this time, flows of foreign FAD, technology licensing and technologies were required and financial and technical collaborations were allowed over a wide range of

industries. In this liberal atmosphere, industrial boom in India started to take off in the late asses.

The policy of import-substitution created and sustained demand for foreign technologies. Foreign collaborations increased six-fold between 1948/55 and 1964/70. The FAD stock more than doubled to Errors million between 1948 and 1964. Technology-related royalty payments Jumped sixteen-fold between 1956/7 and 1967/8. As noted by Ideas (1980), the building of industrial capacity proceeded almost totally on the basis of imported technology, and, in the absence of any need to improve competitiveness, there was little or no incentive to learn, absorb, assimilate and upgrade foreign technologies to create capabilities.

While industrialization proceeded on back of foreign technologies, “ R&D promotion policies focused on creating a scientific and research base” (Gradual 2001). The PR (1958) considered the creation of a scientific base as a pre-requisite for developing the domestic R&D base on the premise that “ technology grows out of the study of science and its application” (Gradual 2001). This stance led to substantial investments in the establishment of science-based educational and R&D infrastructure. The number of engineering colleges and seats rose from 38 and 2940 in 1947 to 138 and 2 25000 respectively in 1970.

In 1968, the Indian Institutes of Technology, modeled on the Massachusetts Institute of Technology, were set up. There was also a rapid expansion of agencies like the Council for Scientific and Industrial Research (SIR), the Department of Atomic Energy and the Defense Research and Development

Organization. Such R&D as was performed at this time was centered on: a) b) c) scaling down of plants based on foreign technology to suit Indian markets adapting foreign processes to Indian conditions and local materials and, tackling on-the-spot reduction problems and quality control.

As Ideas (1980) has put it, this was a period when the emphasis was on R&D with a short pay-off, although it must be said that over the period India built a substantial scientific base and R&D capability. The Restrictive Phase There was a major policy shift in the late asses. A foreign exchange crisis induced the government to pursue a policy of " self-reliance", thereby moving the focus in national planning from merely " growth" to " growth with self-reliance and social justice. Besides, the Monopolistic and Restrictive Trade Practices (MRS.) Act ushered n a period of regulation in which the expansion of large firms was regulated, a reservation policy to protect the small-scale sector was introduced and banks and financial institutions were nationalists to ensure the flow of credit to designated technological self-reliance also became important. The basic stance was that technology should not be imported to the detriment of local development effort and that R&D structures created earlier should be used to meet the industrial demand for technologies (Sandy et al 1990).

To generate demand for domestic technologies, he earlier policies on technology acquisition were reversed and the emphasis was shifted from " science and scientific development" to " technology and technological development" (Gradual 2001). Foreign collaborations were severely restricted and FAD was allowed only in core industries where no alternative local technologies were available. To deal with the situation arising from the

restrictions on technology acquisition, a Department of Science and Technology (DUST) was set up.

S&T planning was made part of the overall planning process in the Fifth Plan (19741979). 13 The impact of these policies is well documented. Technology transfers declined drastically between 1968 and 1980. FAD inflows declined and in the late asses there was a net outflow. Growth of royalty payments slowed, from 22. 3% annually between 197076 to 15. 2% between 1977-85. Having said that, it must be pointed out that some positive benefits accrued. Local R&D activities increased.

R&D expenditures in private companies increased more than eight-fold to Errors million between 1970/71 and 1980/81. The number of registered units in the private sector rose from 156 in 1969 o 516 in 1979. R&D expenditures in the SIR rose from Rests million in 1970/71 to Rests million in 1980/81. This led to near self-sufficiency in standard technologies and India indeed began to export technology. While the above achievements are certainly noteworthy, these policies did not engender a well-performing national innovation system.

The vital ingredients of technology acquisition, technology generation and technology diffusion were not balanced and were not consistent with industrial and macro-economic policies. What is more, the four conditions – strong nominative environment, high quality human capital, well-developed linkages between industry, institutions and academia and access to foreign technologies – were either not tailored to the innovation system or that there

was lack of an appropriate mix of them. Macroeconomic policies stifled all forms of competition.

Industrial licensing suppressed competition from within and restrictive trade and FAD suppressed competition from without. Industrial production growth rates stagnated. Exports grew slowly so that by the late asses, the balance of payments had become a matter of concern. While, India achieved self-sufficiency in technologies for local production and consumption due to the policy of import-substitution and self- reliance, it could not build capacity in world's technologies to produce for international markets (All 1987). Although India achieved proficiency in standard technologies (Bagman 1995).

Not surprisingly, the share of technology intensive imports in total imports rose from 63% in 1970/71 to 10 years later. Total factor productivity declined and became negative (ICC 1994) and its contribution to the growth rate of 3% was as low as 0. 2% between 1970 and 1980 (UNCLAD 1992). At the corporate level, in the closed economy that India was at that time, there was little incentive to improve efficiency of resource use. Besides, the license regime created a market structure off few large firms and a large number of small firms.

While the former lacked the incentive to undertake R, the latter were too small and had limited resources to do so. Policies of the Foreign Exchange Regulation Act (FEAR) and MRS. 14 restricted the growth of large firms, except through diversification. This constituted a serious disincentive for committing resources to R and affected their capability to do so. Not

surprisingly, R expenditures became insignificant. In 1982/3, 55% of private sector R units spent less than RSI million on R, with the average being RSI 0. 5 million, as Gradual (2001) notes. In the absence of the resources and the need to generate new technologies, importation was resorted to. Such imported technology was adapted to local needs, with little effort being devoted to learning, assimilating or improving it. The Liberalized Phase Mid-1991 marks a watershed in this phase. A policy of liberation's and a reversal of the previous inward-looking policy had commenced in the asses but this was a half- aerated and scanty attempt to appease certain sections of the economy.

In the asses, in view of declining exports, worsening balance of payments and stagnating industrial growth spanning over a decade, the Government of India decided to re- orientate industrial and trade policies. The Sixth Plan (1979-84) Document gave a directive of " growth with efficiency" away from the previous " growth with social justice and self-reliance". The Industrial Policy Resolution of 1980 stressed the need for optimal use of resources and higher productivity. It proposed liberation's of the industrial licensing regime (the The process of deregulation was implemented in a license raja) and foreign trade. Umber of industries and some major reforms were introduced in the mid-asses, including reductions in import restrictions and tariffs. With shifts in Plan (Indian's development plans are operated in 5-year blocks) priorities, technology acquired a stronger focus. Restrictions on technology imports and foreign equity participation were relaxed. Up to 51% foreign equity was permitted in many In areas of sophisticated sectors, except in those reserved for the public sector.