Globalization, Markets for Technology and the Relevance of Innovation Policies in Developing Economies

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Globalization, Markets for Technology and the Relevance of Innovation Policies in Developing Economies

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Abstract

Three different connotations of the term "globalization of technology" are discussed. These definitions are then applied to actual data and the phenomenon is thus measured. The measurements point to two opposing schools: one that believes that there is increasing evidence or globalization of technology and another one that believes that there is very little evidence of globalization. The debate on globalization thus brings to the fore the concept of markets for technology. Available empirical evidence shows that this market has become less competitive over time. Implied in this argument is the relevance of innovation policies, defined as instruments and institutions that encourage the local development of technology and the adaptation of imported technologies. The paper concludes by discussing the specific ingredients of such a policy.

Key words: globalization of technology; developing countries; markets for technology; innovation policy; spillover effects, foreign direct investment; research scientists and engineers; tax benefits for R&D

JEL Classification: O31; O38

Introduction

Despite the frequent discussion of the term globalization of technology, the term lacks precision. Different commentators use it to mean different things. Interest in this phenomenon stems from the fact that if there is increasing globalization of technology, it would mean that the markets for technology are becoming very competitive, which in turn should increase the accessibility of countries and firm to state-of-the-art technologies through essentially arms-length transactions. The basic purpose of this paper is to examine whether this proposition is actually true. To achieve this objective the paper begins by spelling out the connotation of the term "globalization of technology". This is followed by its measurement in empirical terms. An allied hypothesis is that if there is indeed globalization of technology—meaning thereby large–scale availability and accessibility of technology—then the markets for technology are becoming more competitive now than ever before. Based essentially on standard indicators we demonstrate that the markets for technologies are actually becoming less competitive or more imperfect. The implications of this for most developing countries is very easy to appreciate, as most of them are mere assemblers of technologies that are products of the developed countries. Irrespective of whether countries are assemblers or generators of new technologies, they require a set of innovation policies that would aid them to do so and it is necessary to spell out the components of these policies.

In keeping with these objectives, the paper is structured into three sections. The first section maps out the various connotations of the term globalization of technology. The second section delineates the concept of a market for technology and analyses whether this market is becoming competitive or not. In the light of the arguments presented in these above two sections, the third section makes a case for innovation policies that governments may put in place to encourage not only local development of technology but also the adaptation of imported technologies to local conditions.

Globalization of Technology-The Three Definitions

Archibugi and Michie (1995, 1997) identified three separate processes that are generally subsumed under the catch-all expression "globalization of technology". According to them the term has three connotations:

- International exploitation of national technological capabilities;
- International technology alliances; and
- Globalization of innovation across countries
- Each of the three categories has its own manifestation and has indicators that can measure it in empirical terms *(Table 1).*

It is thus clear that globalization of technology can therefore entail, one or all of the following:

- The global exploitation of technologies through patents and licenses.
- The global sourcing of research and development (R&D) through alliances and joint ventures with foreign companies or universities.
- The global production of R&D through overseas subsidiaries.

Of the three, it is only the last two that can strictly be termed globalization of technology. I now present the empirical evidence on those two.

Table 1: The Three Definitions of Globalization of Technology

Category	Manifestation	Indicator
1. International exploitation of national technological capabilities	• Domestic enterprises • Exports of high technology products • Relocation of production abroad • Exports of disembodied technology through the medium of licensing agreements between foreign and domestic firms	• International trade in high tech products • Quantum of FDI inflows and outflows • Number of licensing agreements
2. International technology alliances (collaboration across borders among both public and business institutions to exchange and develop know-how)	• Firms expand their non-equity agreements to share costs and risks of industrial R&D	• Number and form of scientific and technical agreements as given by the MERIT-CATI database on strategic technology partnering
3. Generation of Innovation across more than one country	• MNCs establish their R&D units abroad	• Degree of R&D financed from abroad • Patenting activities of MNCs attributable to research in foreign locations

International Technology Alliances

Industrial firms increasingly have sought global research partnerships as a means of strengthening their core competencies and expanding into technology fields considered critical for maintaining market share.[7] Technological complementarity and reduction of

7 This section is based on the data contained in the data set known as MERIT-CAT. The MERIT-CATI database contains more that 10,000 inter-firm cooperative agreements involving thousands of different parent companies. In the CATI database, only agreements that contain arrangements for transferring technology or joint research are collected. These counts are restricted to strategic technology alliances, such as joint ventures for which R&D or technology sharing is a major objective, research corporations, joint R&D pacts, and minority holdings coupled with research contracts. CATI is a literature-based database; its key sources are newspapers, journal articles, books, and specialized journals that report on business events. CATI's main drawbacks and limitations are that (1) data are limited to activities publicized by the firm, (2) agreements involving small firms and certain technology fields are likely to be underrepresented, (3) reports in the popular

the innovation period are primary catalysts for entering into a core technology alliance; market entry and production-related factors are more relevant in technologically less advanced or mature markets. Though difficult to define in very precise terms, there is widespread consensus that: (a) strategic alliances are not primarily direct investments but not arm's-length relationships either and; (b) the notion of alliances assumes the existence of distinctive or relatively independent agents. Their growth of alliances was very fast during the 1980s but involved predominantly companies from the US, Western Europe and Japan (Freeman and Hagedoorn, 1994). These new forms of agreements are not replacing but actually complementing and expanding traditional foreign direct investment (FDI). According to Hagedoorn (1996), a large share of the population of strategic technology partnerships is still of an intraregional or domestic nature. Although this share has declined over the past decades, from an average of about 50% for most of the 1980s to somewhat higher than 40% during the early 1990s, it is still the single largest group of alliances. Only during a few years has the share of international, inter-Triadic alliances been higher than the domestic and regional alliances. During the most recent years there has been a growth of alliances with companies from the newly industrialized companies (NICs), in particular from Korea, Taiwan, Singapore and Hong Kong. For the decade since 1986, growth in core technology alliances has been continuous though irregular. Of the roughly 2,500 information technology alliances formed during this period, the largest number has been among U.S. companies and between European and US firms. Among the 1,100 strategic biotechnology alliances, US–European interregional partnerships have been more prevalent than any other, especially during the mid-1990s. In fact, by 1996 almost 60% of all biotechnology collaborations were interregional. The opposite was true of partnerships focusing on information technology, for which intraregional alliances were created twice as often as interregional partnerships in 1996.

Two major conclusions emerge from these studies as far as the developing countries are concerned. First of all, the share of developing countries in such strategic technology partnerships[2] is very low (about 4% during the period 1980–1989 according to Freeman and Hagedoorn, 1994. In the period between 1989 and 1992 there were some slight increases (Hagedoorn, 1996), but these were confined to the four East Asian tiger economies of South Korea, Taiwan, Singapore and Hong Kong and as such were not widespread. The second aspect is that if one decomposes these strategic technology partnerships (between the developed and the developing countries) into four categories according to their mode of cooperation, such as joint ventures, joint R&D, minority investments and others such as R&D contracts, etc., over two-thirds of the partnerships are in the form of traditional joint ventures. The share of joint R&D agreements does not

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press are likely to be incomplete, and (4) it probably reflects a bias because it draws primarily from English-language materials. CATI information should therefore be viewed as indicative and not comprehensive.

[2] Freeman and Hagedoorn (1994) defines strategic technology partnership as those inter firm agreements for which joint R&D and/or other innovative activities are part of the agreement and that can reasonably be assumed to affect the long-term product market positioning of at least one partner

[3] However the major reasons for these partnership is to be seen in the availability of highly skilled personnel to the TNC. Given the fact these linkages are very recent, it is a bit too early to measure its spillovers to the country at large.

make up more than 14% most of which are once again concentrated in the tiger economies of East Asia. However, among the non East Asian developing countries, India is an important exception as it features some examples of government research institutes attracting research contracts from multinational corporations (MNCs) UNCTAD, 1999b)[3]. Thus, based on this indicator, it is safe to conclude that that there is very little empirical evidence of any globalization of technology as far as the majority of the developing countries are concerned.

Generation of Innovation Across More than One Country

Of the three definitions given earlier, this is the most prominent connotation of the term globalization of technology. Studies analyzing the internationalization of corporate R&D are largely based on two sets of measures:

- ***R&D Expenditures and employees:*** The Organization for Economic Cooperation and Development (OECD, 1999a) has recently brought together evidence from national surveys on the shares of domestic business funded R&D performed by foreign firms, and of R&D funded by domestically owned firms that is performed outside their home country.
- ***Patent statistics:*** Several researchers (Patel and Pavitt, 1998) have used this methodology, which allows the inventor's address as given in each published patent to stand as a proxy measure for the geographical location of R&D activities.

There are, as well, two sets of empirical evidence: one that states that globalization is on the increase and the other that finds very little evidence for globalization. These are analysed in turn.

Globalization of Innovation is on the Increase: Empirical Evidence

Much of the of the evidence on increases in globalization is to be found in two different studies by the OECD.[4] These studies have used three separate indicators to measure globalization:

- Share of foreign affiliates in domestic manufacturing R&D
- Share of domestic industrial R&D financed from foreign sources
- Cross-border ownership of innovations

Share of Foreign Affiliates in Domestic Manufacturing R&D

Although R&D in many countries is less internationalized than production, there have been significant increases in certain countries (namely, the United States, France, Sweden and the United Kingdom) in the past 15 years. The share of foreign affiliates in R&D varies widely across countries, ranging from less than 2% in manufacturing industry in Japan to 68% in Ireland. The differences among countries reflect primarily the contribution of foreign affiliates to industrial activity in those countries. Thus the share of foreign affiliates in manufacturing production is high in Ireland and low in Japan. Similar data on developing countries are extremely hard to come by.

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[4] See OECD (1999 a and b).

Table 2: Share of Foreign Affiliates in Manufacturing R&D in OECD Countries

	1985	1996
Canada	44.2	40.3
United States	5.9	12.0
Australia	46.4	37.6
Japan	1.0	1.3
Czech Republic	-	30.9
Finland	-	11.5
France	10.1	21.0
Germany	-	14.5
Greece	9.2	10.1
Ireland	63.1	68.0
Italy	-	23.1
Netherlands	-	18.0
Poland	-	13.9
Spain	46.4	42.7
Sweden	8.2	18.7
Turkey	-	16.1
United Kingdom	18.0	39.5

Source: OECD (1999b), p.162

Share of Domestic Industrial R&D Financed from Foreign Sources

With the exception of Japan, the seven largest R&D performing countries have all seen a considerable rise in the percentage of R&D expenditures financed from foreign sources since 1981. There are of course problems with respect to the estimation of foreign contribution, as not even all the OECD countries keep track of this particular statistic on a systematic basis.

Cross-border Ownership of Innovations

Cross-border ownership of patents reflects the inventive activity of foreign affiliates of MNCs. On average, 8% of inventions made in any OECD country were owned by a foreign resident in the mid-1990s, against 6% in the mid- 1980s. For almost all countries, both ownership of invention abroad and foreign control of domestic inventions have increased.

Ownership of inventions made abroad is high in small open countries such as the Netherlands and Switzerland. These two countries and the United States are the largest owners of patents covering foreign inventions; however, because of the size of the United States, the share of foreign inventions is just above the OECD average. Japan and Korea are much less internationalized in this respect.

All the foregoing evidence refers only to the OECD countries. However even for these developed countries, I present below the contrary evidence.

Globalization of Innovation is not on the Increase: Empirical Evidence

I hold the view that what is happening in terms of R&D centres moving abroad is a developed country phenomenon and as such it does not affect the majority of the developing countries. This inference is based on an analysis of the evidence presented in a number of recent studies, particularly two studies by US government agencies and the one by Patel and Pavitt (1998).

The US Government Studies

The US government has been particularly worried about its firms establishing R&D centres abroad. This worry stems from two pertinent but unrelated facts: First is a feeling among some analysts that the American innovation system could "hollow out". In particular, developing countries (like Korea and India) are making important investments in high-technology sectors. This feeling has forced some analysts to raise the following questions: (a) What stops these developing countries from becoming new Japans? (b) Is technology transfer between countries accelerating? (c) Is the technological superiority of the developed world more precarious than in the past? Second is a feeling among the US policy makers that US MNCs, while taking advantage of various fiscal incentives for R&D extended to them by the federal government, are actually locating their R&D outfits abroad. This feeling has prompted the US government to commission two separate studies on the globalization of industrial R&D by the US MNCs. The first one is through the now defunct Office of Technology Assessment (OTA, 1994) and the second is through the Council on Foreign Relations (1998). I consider the evidence presented on the issue by both these studies, beginning with the one by OTA.

The OTA Study

Although the volume of overseas R&D by affiliates has increased substantially, it is still a small fraction of R&D conducted by MNCs. Like the aggregate level of R&D spending, the R&D intensity of foreign affiliates tends to be substantially lower than that of parent groups. Much of the growth in R&D of both foreign affiliates in the United States and US affiliates abroad can be attributed to overseas acquisitions and/or joint ventures,[5] and consequently does not necessarily represent a transfer of R&D operations from the home country to foreign markets. However, the role of FDI in launching and stimulating local R&D in developing countries is very limited. To illustrate (Figure 1), in the case of the US MNCs, R&D by developing country affiliates came to only 8.86% of total overseas spending, or 1% of parent company R&D in 1994. Even what existed was highly concentrated. Brazil by itself accounted for over one-quarter of affiliate R&D in the developing world. The top four countries, with Mexico, Singapore and Taiwan Province, accounted for 77.4%. Least developed countries had no significant R&D.

5 According to the *Trade and Development Report 1999 of the UNCTAD*, the Mergers and Acquisitions (M&A) in developing countries accounted for well over half the total FDI inflow in 1992-1997 and almost three quarters if China is excluded.

Further even the share of developing countries in the overseas R&D by affiliates of US MNCs does not show an increasing trend.

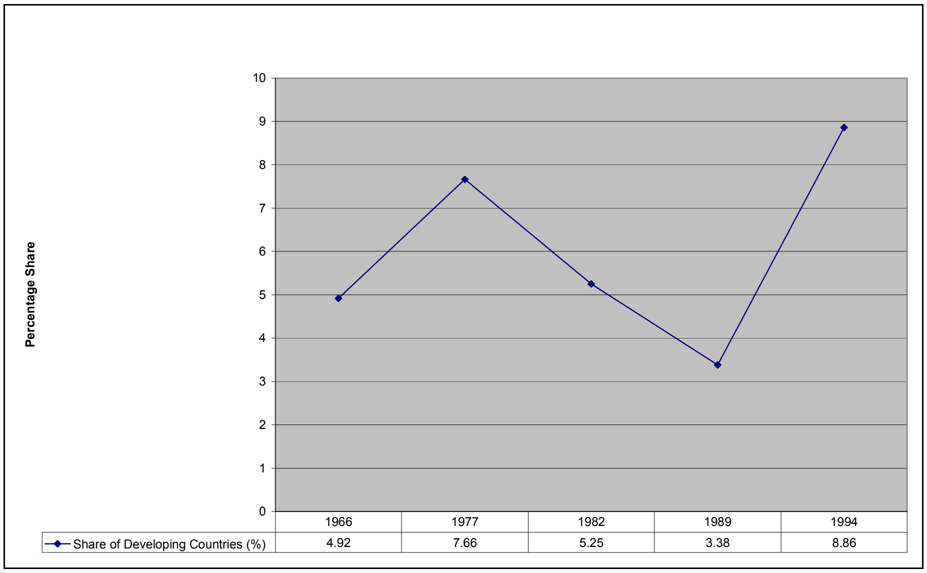


Figure 1: **Share of Developing Countries in the Overseas R&D Expenditure by the Affiliates of US MNCs**

(Source: OTA (1994)

Although relatively low, the rapid increase in both the magnitude and the intensity of overseas R&D by foreign affiliates does represent a gradual globalization of R&D. But it is extremely difficult to assess the significance of this trend because of the lack of data on the technological and strategic contribution of the R&D conducted by foreign affiliates. The important analytical task is to determine whether R&D conducted by foreign affiliates contributes to the core technological activities of the parent firms, or whether it contributes to the product and process technology used by overseas production facilities. The study by Kuemmerle (1997) to a certain extent answers this point.

According to Kuemmerle, firms tend to adopt a global approach to R&D for one of the two basic reasons:

- Multinational firms seek a foreign R&D presence to support their overseas manufacturing facilities or to adapt standard products to the demand in those regions. This arrangement is referred to as the home-base exploiting site, where information tends to flow to the foreign laboratory from the central laboratory at home.

- The foreign site is established to tap knowledge from competitors and universities around the globe. This is referred to as the home-base augmenting site and in this case the flow of information is from the foreign laboratory to the central home laboratory.

Kuemmerle's study of 238 foreign R&D sites showed that a majority of them (55%) were of the home-base augmenting type.[6] For developing countries to benefit from MNC investment in overseas R&D it should be more of the of the home-base exploiting variety as that is the only one where some spillover from such investments can occur to the host country.

The Council on Foreign Relations Study.

This study is based on a case-by-case analysis of R&D globalization in several technology-intensive industries: software, semiconductors, industrial chemicals, medical devices and pharmaceuticals. The industries were chosen because the type of research they perform differs along dimensions that would be expected to result in distinct globalization patterns. The study has found that the offshore sourcing of R&D by MNCs—through alliances and joint ventures, and offshore development of new ideas and products through subsidiaries—has the following four characteristics:

- It is occurring at a modest pace, with the majority of industrial R&D still done in the company's home country.
- It varies considerably across industries in its pace, extent and nature.
- It is primarily a first world phenomenon because the developing countries, even the advanced ones, are marginal participants in industrial research. Although on the rise, a relatively small percentage of US R&D is performed in the developing world (Table 3).
- R&D globalization has primarily benefited the US economy because the United States has remained an attractive research site for foreign MNCs.

Most studies indicate that over time and across countries the most significant reason for conducting R&D in foreign markets is to customize products to local market conditions. Fully integrated affiliates that conduct independent product R&D are relatively rare. In sum, R&D moves overseas much more slowly than production, sourcing and other business activities.

6 This finding has been confirmed by a more recent study by Dalto, Serapio and Yoshida (1999). According to them, " Motives for establishing overseas R&D facilities are manifold and differ among industries; technology or supply-oriented reasons have increasingly influenced the decision of U.S. firms to locate R&D abroad (a home-base augmenting strategy). This trend is particularly true for electronics and computer software. Even when companies initially invested abroad for the purpose of assisting their manufacturing/sales/service facilities in a local market (a home-base exploiting strategy), they increasingly are positioning these R&D facilities as regional R&D bases".

Table 3: Source of Patenting of the of the Largest Firms in the World

Nationality	**Percentage Share of US Patents in 1992-96**		**Percentage Share of R&D Expenditure Abroad**	**Change in percentage of patents abroad since 1980-84**
	Home	**Abroad**		
Japan	97.4	2.6	2.1 (1993)	-0.7
US	92.0	8.0	11.9 (1994)	2.2
Europe	77.3	22.7		3.3
Belgium	33.2	66.8		4.9
Netherlands	40.1	59.9		6.6
Switzerland	42.0	58.0		8.2
UK	47.6	52.4		7.6
Sweden	64.0	36.0	21.8 (1995)	-5.7
France	65.4	34.6		12.9
Finland	71.2	28.8	24.0(1992)	6.0
Italy	77.9	22.1		7.4
Germany	78.2	21.8	18.0(1995)	6.4
All Firms	**87.4**	**12.6**	**11.0 (1997)**	**2.4**

Source: Patel and Pavitt (1998)

The Patel and Pavitt Study

This study is based on the patenting behaviour of 359 of the world's largest firms (European = 136, American = 128 and Japanese = 95) from the Fortune 500 list. (See Table 3) First it shows that for an overwhelming majority of the firms R&D is still conducted within the home country and not abroad. Only for smaller European countries such as the Netherlands, Belgium and Switzerland does a majority of the patents originate from research done abroad. But for these countries this has been the case for a very long time in view of the small size of their home economies and the resultant short supply of skilled personnel and other key resources for conducting R&D. Second, the position is exactly the same if one uses R&D data instead of patent data. Third, if one considers the patent data, there was hardly any change in the patenting behaviour of these firms in the 1990s or the change was too small for most countries when compared with the 1980s. In short, this study too confirms the view that there is very little evidence for an increase in the internationalization of corporate technology.

Finally the main conclusion that one can draw from all these studies is that although there is some limited evidence for globalization of technology, it is restricted to the United States, Western Europe and Japan. At best some developing countries are in receipt of foreign R&D centres, but the share of R&D expenditure of these foreign R&D centres in the total industrial R&D expenditures of these countries is insignificant.

Even according to OECD (1999a), the data on patenting remind us that R&D globalization is not entirely new. When one calculates the share of patents based on research done by US and European firms, one sees that some industries and some countries were already as global in the 1920s and 1930s as they are in the 1990s. British, Dutch and Swiss companies performed a significant share of their R&D abroad during the inter-war period—nobody called that globalization of technology at that time.

Markets for Technology

Implicit in the "globalization" argument is another one, namely that markets for technologies exist and that with globalization the barriers to entry into this market are being lowered, leading to increased competition among the so- called technology suppliers. This state of affairs of increased competition is said to be beneficial to developing countries as they are supposed to be able not only to benefit from increased access to, say, state-of-the-art technology but also to obtain it in terms of better terms and conditions (referred to as at arm's-length prices). But "markets for technology" is a rather elusive concept as the product (namely technology) that is bought and sold in the market is very often intangible. This renders any attempt to outline the contours of this market a very difficult task. Nevertheless, Arora et al. (1999 and 2000) recently attempted not only to define it but also to provide some estimates of its physical size in value terms. According to them, "technology transactions can take different forms, from pure licensing of well defined intellectual property, to complicated collaborative agreements which may well include the further development of the technology, or its realization *from scratch*". Though transactions in technology can also occur through mergers and acquisitions and through the mobility of people, the authors do not include these models in their definition because of the extreme difficulty in measuring these components. They estimate the value of technology transactions of all countries as follows:

- The value of the transactions consists of the licensing and royalty payments, equity purchase in technology source, and R&D funding to technology source.
- Each transaction was verified to ensure that it involved a transfer of technology.
- The firm(s) granting the technology were coded separately from the firm(s) receiving the technology.
- In case of a cross-licensing agreement, the value was split equally between the firms.

The estimates so arrived at are presented in *Table 4.* In measuring the relative size of the value of the market for technology I take it as a percentage of the business enterprise R&D expenditure of all the developed economies (OECD). The table brings out several interesting details. First of all, the market for technology does not show a definite increasing trend, but only fluctuations. In fact, there has been considerable shrinkage in its size and growth since the mid-1990s. This is quite compatible with the fact that increasingly, many of the technologies are getting transacted through non-market forms: the substantial growth of FDI during the period substantiates this point. Second, the market for technology is actually very small even though it has showed some increases during the early part of the last decade.[7] The implications of these two results for the developing countries are discussed below.

Table 4: Size of the Market for Technology, 1985-1997

(1)	Market for Technology (Millions of Current $) (2)	Rate of Growth of the Market (%) (3)	Business Enterprise R&D (Millions of Current PPP $) (4)	Relative Size of the Market for Technology (5 = 2/4*100)
1985-89	27753			
1990	24169	-12.91	237603	10.17
1991	41410	71.34	250366	16.54
1992	43571	5.22	256922	16.96
1993	46479	6.67	254090	18.29
1994	51604	11.03	259808	19.86
1995	44469	-13.83	292272	15.21
1996	20761	-53.31	313056	6.63
1997	21956	5.76	NA	

Source: Arora et al. (2000) and OECD (1999c).

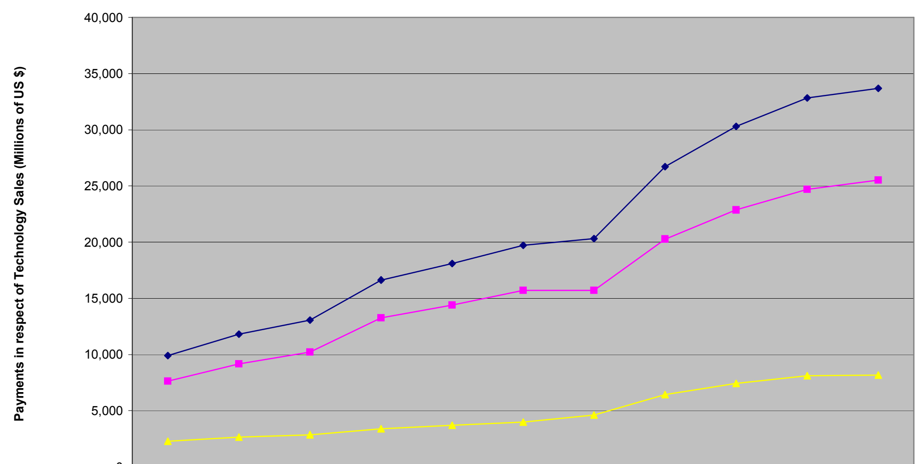
It is seen that non-market forms of technology transfer are on the increase. This means that increasingly technologies are being transferred through the intra-firm route. To illustrate, parent companies are selling technologies more to their affiliates and conversely less to unaffiliated firms. Recent data clearly substantiates this point. Both Korea and India have traditionally used the medium of purchasing technology through the market by means of licensing agreements. Of late the number of cases of licensing agreements that are approved has come down in both of these countries while the relative share of technical collaboration agreements involving equity participation by the collaborator (no-market forms) is clearly on the increase in both countries.

United States is the world's largest net seller of technologies to the rest of the world (as indicated by its consistent positive technology trade balance). Increasingly, however, the share of receipts from the sale of technology by US firms to unaffiliated companies or firms abroad has decreased (Figure 2). The figure indicates that there has been a

[7] My estimates of the size of the market are slightly different from Arora et al. (1999c). They have estimated it to be around 5% of the total non-defense R&D of the developed countries and therefore it is clearly an underestimate. By contrast, my estimates are likely to be overestimates as the business enterprise R&D figures are in current purchasing power parity dollars while the value of the market for technology figures are in current US dollars. In all probability, Arora et al. might have converted national values of technology transactions into US dollars using the official exchange rates rather than purchasing power parity terms.

significant reduction in the rate of growth of sales of technology to unaffiliated firms since 1994, thus confirming my earlier proposition.

In Table 5, I do a further exercise by decomposing the sale of this disembodied technology to unaffiliated enterprises in the developing world. The exercise shows that while the sale of technologies to developing countries has almost doubled (as measured by the share of developing country sales to total sales) during the period under consideration, this is entirely due to the sale of technologies to just two countries, Korea and Taiwan. Net of these two, the share of developing countries has remained virtually stagnant.



	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Receipts	9,914	11,802	13,064	16,634	18,107	19,715	20,323	26,712	30,289	32,823	33,676
Affiliated	7,629	9,156	10,207	13,251	14,395	15,718	15,707	20,275	22,859	24,710	25,515
Unaffiliated	2,285	2,646	2,857	3,384	3,712	3,997	4,616	6,437	7,430	8,113	8,161

Figure 2: US sale of disembodied technology to affiliated and unaffiliated enterprises abroad, 1987–1997

Source: National Science Board (2000).

From the foregoing analysis, the following conclusions emerge:

- The so-called market for technologies is actually small and is shrinking over time.
- Much of the sale of technologies to enterprises in developing countries takes place through non-market forms such as FDI.

In the light of this it will be very instructive to find out whether there exists any systematic evidence of the spillovers from FDI especially in the developing world. This is attempted in the following section.

Table 5: US Sale of Disembodied Technologies to Developing Countries (Millions of US $)

	Asia	Latin America	Africa	Middle East	Total Developing Countries	Total Developing Countries excluding Korea and Taiwan	All Countries
1987	213	64			277	222	1,678
1988	302	48	22	18	390	237	1,962
1989	351	54	24	17	446	245	2,051
1990	437	59	22	22	540	236	2,333
1991	419	85	34	25	563	281	2,434
1992	436	73	27	21	557	295	2,525
1993	532		36	33	601	289	2,820
1994	691	83	26	20	820	385	3,026
1995	914		35	35	984	297	3,513
1996	850		28	23	901	294	3,488
1997	912	69	17	40	1038	499	3,272

Source: Computed from National Science Board (2000).

Evidence of Technology Spillovers from FDI

It is argued that when firms establish affiliates abroad and become multinational, they are distinguished from the already established firms in the host country by two factors:

- They bring with them some amount of proprietary technology that constitutes their firm-specific advantage and allows them to compete successfully with local firms who have superior knowledge of local markets, consumer preferences and business practices.
- The entry of the MNC affiliate disturbs the existing equilibrium in the market and forces local firms to take action to protect their market shares and profits.

Both these factors are likely to cause various types of spillovers that lead to productivity increases in local firms. There are *three* types of spillovers:

- Perhaps the simplest example of a spillover is the case where a local firm improves its productivity by copying some technology used by MNC affiliates operating in the local market.
- A second kind occurs if the entry of an affiliate leads to more severe competition in the host economy, so that local firms are forced to use existing technology and resources more efficiently.
- A third type of spillover effect takes place if the competition forces local firms to search for new and more efficient technologies, as the entry of a foreign affiliate may demonstrate the existence and profitability of new products and processes, and encourage local firms to adopt some of them. These diffusion processes may even be repeated every time innovations are transferred.

A detailed survey of the various studies is provided in Blomstrom and Kokko (1997). To examine how the development of technology and productivity in individual local firms is related to the presence of foreign MNCs in the local market, a study would require detailed micro data, both qualitative and quantitative. The study would have to cover several years, as spillovers are not instantaneous. It should also indicate a large number of firms and industries, so that inter industry spillovers could be observed, and so that it would be possible to reach statistically significant conclusions. According to Blomstrom and Kokko, however no comprehensive analysis of this character has ever been made, essentially because of the extreme data requirements. Additional empirical evidence on spillovers must therefor be drawn from two other sources.

First, in addition to the few case studies focusing directly on spillovers, there are large numbers of case studies discussing other aspects of FDI in different countries and industries; these studies often contain valuable "circumstantial evidence" of spillovers. For instance, many analyses of the linkages between MNCs and their local suppliers and subcontractors have documented learning and technology transfers that may make up a basis for productivity spillovers or market access spillovers. These studies seldom reveal whether the MNCs are able to extract all the benefits that the new technologies or information generate among their supplier firms, so there is no clear proof of spillovers, but it is reasonable to assume that spillovers are positively related to the extent of linkages There are also studies of demonstration effects, technology diffusion and labour training in foreign MNCs.

Second, there are a few statistical studies examining the relationship between a foreign presence in a host country industry and the productivity (or productivity growth) of the locally owned share of the industry or of individual locally owned firms. These studies typically estimate production functions for locally owned firms, and include the foreign share of the industry as one of the explanatory variables. They then test whether foreign presence has a significant positive impact on local productivity (or productivity growth) once other firm and industry characteristics have been accounted for. Although the data used in these analyses are often limited to few variables, aggregated to industry level rather than plant level, and in several cases of a cross-section rather than time series or panel character, they do provide some important evidence on the presence and pattern of spillover effects.

In short, the evidence on positive spillovers from FDI, from anywhere in the developing world, is not easy to come by. However, two developing countries, Singapore and Malaysia, have benefited from FDI. But Mani (2000) shows that Singapore has actually engineered spillovers from FDI by putting in place a host of target-oriented innovation and industrial policies such as the Local Industry Upgrading Programme". [8] Consequent to this, there has been a significant spurt in the number of local small and medium enterprises and of late the ratio of R&D expenditure of local firms to foreign firms is greater than unity in a number of manufacturing industries such as precision and transportation engineering and service industries as a whole. In the case of Malaysia the picture is entirely different. FDI has played an important role in this transformation and the spectacular expansion and structural changes in the composition of manufactured exports. Manufacturing is dominated by a few industries, notably the electrical and electronic industries, making the economy vulnerable to changes in world demand for the products involved. The most important industry is electrical machinery, appliances and parts. This industry, in which foreign affiliates are prominent, is characterized by high import intensity and limited technology transfers and backward linkages. The share of value added is relatively low and has even declined over the years from 28% of gross output in 1981 to 22% in 1992. A survey of 18 of the largest foreign affiliates in the

8 Under the Local Industries Upgrading Programme (LIUP), the government encourages MNCs to "adopt" a group of small and medium enterprises (SMEs) and transfer technology and skills to them. The government pays the salary of a full-time procurement expert to work for specified periods with the adopted firms and help them upgrade their production and management capabilities to the standards required. In this way the state engineers positive spillovers from FDI to the local small and medium sector.

industry carried out in 1995 showed that the value of imported materials and components accounted for 78% of their total inputs (UNCTAD, 1999a). However there are encouraging signs of foreign affiliates forging backward linkages and there are indications of technological deepening and upgrading. A principal constraint is the shortage of skilled personnel and of substantial investments in R&D. and this is the challenge facing the policy makers in that country.

My analysis thus far brings to the fore the following propositions with respect to technology development in developing countries. First, globalization of technology has affected developing countries only in an insignificant manner. The process does not affect the majority of the developing countries at all. Second, the markets for technology are shrinking and appear to be not very competitive. Increasingly, moreover, much technology is being transferred to the developing countries through non-market forms like FDI. The evidence on positive technology spillovers from FDI to local firms is very limited, but some countries have been successful in engineering it through ingenious policies. This raises some questions about the continued relevance of governments' innovation policies designed to give their national firms an advantage. This forms the focus of the next section.

Innovation Policies – Their Relevance and Components

It is essential, at the very outset, to define what I mean by innovation policies. I define these as those efforts by governments, that encourage the accumulation, diffusion and commercial use of new products, processes and services by firms.[9] The basic rationale behind public innovation policies is to combat private under-investment in R&D. Following Leyden and Link (1992), the scope of public innovation policies can be divided into two: First is the creation and maintenance of a legal environment conducive to private sector investment in innovative activities. This is created by legal measures that enhance the power to appropriate the fruits of R&D. Patents and the relaxation of antitrust activity are the primary means by which the government creates such a conducive environment. The second category comprises the provision of sufficient stimuli to overcome the natural inclination of private agents to consider only their private benefits when choosing the level of innovative activity in which to engage. This takes a variety of forms, ranging from government grants and contracts to targeted tax incentives. Public innovation policies vary significantly across countries[10] according to the nature of their development. Table 6 summarizes the main components of these policies.

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9 This definition is very similar to the one by Dodgson (1999)

10 According to World Bank (1998), public innovation policies should consist of: (a) Governments encouraging research either directly through public R&D or indirectly through incentives for private R&D. Direct government R&D includes that financed at universities, government research institutes, science parks and research-oriented graduate schools. Indirect support for R&D includes preferential finance, tax concessions, matching grants, and the promotion of national R&D projects. (b) Governments developing core strengths in basic science and technology, as that is not only necessary to maintain access to the global pool of knowledge but also to adapt that knowledge to local use.

Table 6: Components of Innovation Policies

Type of Measure ⇒ **Relationship with the Market ⇓**	**Financial Measures**	**Non-Financial Measures**
Public provision of goods and services	• Subsidizing exchange of R&D personnel between public and private sectors	• Policies aimed at diffusion of technology • Human resources development policy • University and government R&D • Industrial standards
Modification of market incentives	• Tax incentives for R&D • Direct funding through grants, soft loans, loan guarantees for R&D projects; • Promotion of national R&D projects; • Joint cooperative R&D projects between government and the private sector	• Public procurement • particularly in defence • The IPR regime • Industrial and trade policies
Support of the improvement of market mechanism	• Creation or improvement of specialized financial market mechanisms (e.g., venture capital)	

Source: Mani (2001).

Of the various policies it has been the financial measures and among them the tax incentives that have attracted much attention and analysis. Tax incentives possess a number of attributes that are palatable to policy makers during a phase of economic liberalization. The main popularity of the tax incentive system arises from the fact that it interferes less with the market mechanism. So it is not surprising that public innovation policies have become equated, very narrowly, with tax incentives and other financial measures. However, in current discussions—and these too in the context of developing countries—some of the non-financial measures are equally important. Among them we focus our attention on two: human resources and industrial standards. This is because, as mentioned before, innovation policies will have to undergo significant changes according to the potential technological capability of a country. For instance, developing countries can no longer be considered as a homogenous bunch especially in terms of their technological capability. Some developing countries (such as the east Asian and some Latin American countries) are creators of technology, while others (such as all the countries in sub-Saharan Africa and some countries in South Asia, Latin America and the Middle East) are mere assemblers of technology imported from elsewhere.[11] I denote the former group as Type 1 and the latter as Type 2. For the Type 1 countries, I argue that the financial measures are more important and effective, while for the Type 2 group of technology assemblers it is the non-financial measures that must precede or must receive more emphasis than the financial measures. So I begin with the non-financial measures. It must be mentioned, however, that the basic objective of all innovation policies is to increase the supply of technologies to local firms. Yet it is now well known that merely increasing the supply of technologies need not necessarily lead to positive or desirable outcomes for the economy as a whole. This is because increases in supply must be matched by increases in the demand for technology (Kim, 1997). Most developing countries are characterised by low levels of demand for technologies consequent to the high barriers to entry (both domestic and foreign as well) and therefore domestic firms have little or no real incentive to effect technological improvements: the Indian passenger car market is a good example of this point. The technological development of successful east Asian countries such as Korea (Kim, 1997) has shown that innovation policies must be backed by trade and industrial policies that increases the demand for innovations.

Non-Financial Measures

Policies on Human Resources Development

In my view, this is the most important measure to stimulate domestic technology development. The importance of the availability of a steady stream of highly trained personnel hardly needs to be emphasized. All successful countries including the recent success stories from East Asia had successful policies for increasing both the quality and the quantity of technically trained personnel (Lall, 1998). Most developing countries, however, treat policies on human resource development separately from public innovation policies. Unless there is a critical mass of technically trained personnel, no amount of fiscal incentives can spur innovations. There are two separate but related statistics which capture this state of affairs: (a) the density of tertiary students (Table 7), and the availability of this affects the second one, (b) the density of research scientists and engineers (RSE) (Table 8). In fact as can be seen in Table 8 there is a very strong

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11 More rigorous criteria for arriving at a taxonomy of developing countries ARE attempted in Mani (2000). I use two measures of "revealed technological capability", namely (a) the number of patents received in the US and (b) the share of high technology exports in a country's manufactured exports in classifying developing countries into Type 1 and Type 2 countries.

positive correlation between the RSE and the research intensity: the zero-order correlation coefficient between the two works out to (+) 0.88. Moreover, the number of students enrolled at the tertiary level in science and engineering subjects does not work out to more than 15 to 20% in most developing countries. A third point, which is usually forgotten, is that it is not merely the supply of technically trained personnel that matters. There has to be a match between the requirements of industry and the output of the higher education system. Failure to recognize this can result in losing important markets. For instance, the number of students in IT related subjects are extremely low in most developing countries[12] with some notable exceptions.

Table 7: Density of Tertiary Students (Per 10, 000 Inhabitants)

	Brazil	China	Korea	Malaysia	Singapore	India	Tanzania	Uganda	Zambia	Nigeria
1980	1,158	166	1,698	419	963	515	22	45	128	229
1985	no data	328	3,568	595	1,474	582	22	69	181	352
1990	1,082	331	3,946	680	1,846	582	26	107	212	no data
1991	1,077	313	4,071	753	1,956	no data	28	126	no data	no data
1992	1,042	313	4,375	856	2,080	no data	29	124	no data	no data
1993	1,067	377	4,420	886	2,273	no data	33	135	no data	410
1994	1,092	437	4,637	973	2,328	538	36	150	238	no data
1995	no data	461	4,950	1,048	2,527	610	43	160	no data	no data
1996	1,424	473	5,605	no data	2,730	638	48	179	no data	no data
1997	no data	488	6,106	no data	no data	no data	57	no data	no data	no data

Source: Human Capacity Development Center (2000)

Industrial Standards

Most developing countries pay scant attention to the issue of industrial standards. But this is going to be an important consideration if they want to emerge as manufacturers and exporters of manufactured products especially to the western markets. Industrial standards are an integral component of public innovation policies (Ergas, 1987). They confer at least two major benefits. The first comprises of what may be termed as direct benefits and the second indirect benefits. These are discussed, albeit briefly, below.

[12] There is a shortage of IT related technicians even in advanced countries such as the United States and Germany, but these countries have the luxury of allowing in-migration of these personnel.

Table 8: Density of Research Scientists and Research Intensity (per 1 million labour force)

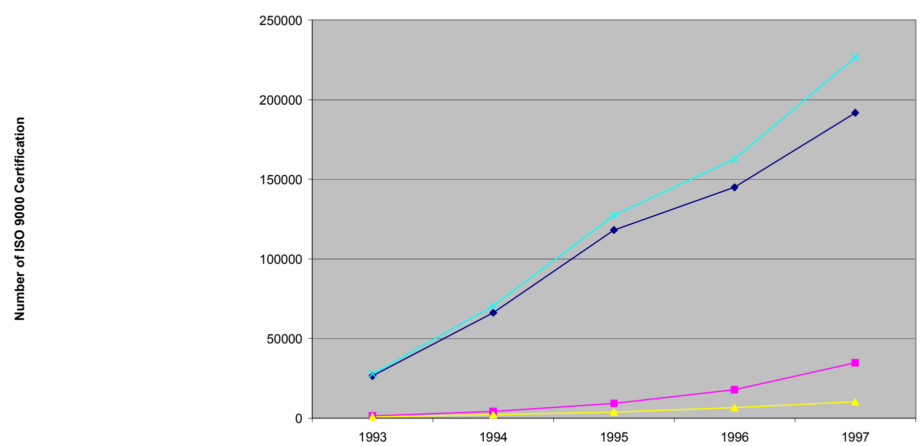
Country	Year	Researchers per 1 Million Labour force	Research Intensity (R&D/GNP*100)
USA	1993	3676	2.63
UK	1996	2448	1.95
Germany	1995	2831	2.41
Korea	1996	2193	2.82
Singapore	1995	2318	1.13
Malaysia	1996	93	0.24
India	1994	149	0.73
China	1996	454	0.66
Brazil	1995	168	0.84
South Africa	1993	1031	0.70
Nigeria	1987	15	0.09
Uganda	1997	21	-

Source: UNESCO (1999)

The immediate impact of standardization is to reduce transaction costs by providing clearly specified interface requirements for products. It can thus lower barriers to market entry and speed up competition and hence demand for new technologies. In other words, though it is a supply-side measure, it has the potential of stimulating demand for technological improvements as well. Further, it fulfills a quality certification function, which is especially important for industrial components. In terms of indirect benefits the preparation of new standards and the ongoing review of existing ones provides an important forum for the exchange of technical information both within each industry and within its users and suppliers. Ergas (1987) thus argues that It can also function as a means of placing ongoing pressure on firms to upgrade their products, while providing them with the technical information required to do so.

Finally, under the Technical Barriers to Trade (TBT) Agreement, which was part of the WTO Treaty signed in 1994, all the signatory governments are obliged to give preference to international standards as a basis for their technical regulations. In addition, the TBT Agreement encourages national and regional standards developers to defer to international standards in their activities. The motivation for this agreement is the long-term goal of free trade across the world. If trading partners adhered to identical, or equivalent, standards, then the costly problem of satisfying arbitrary technical requirements peculiar to nations or regions would be reduced substantially.

For a credible presence in international markets, certification under ISO 9000 standards has become increasingly important for manufacturing and service sector units the world over .[13] ISO 9000 (first published in 1987 and revised in 1994) is primarily concerned with quality management. The definition of quality in ISO 9000 refers to all those features of a product or a service that are required by the customer. Though the share of developing countries in the ISO 9000 certification has shown increases, there is considerable concentration of it within the east Asian countries (the traditional Asian tigers plus China, Malaysia, Indonesia, Thailand and Philippines). In fact, the number of ISO 9000 certifications secured by firms in developing countries excluding the east Asian ones has actually increased very slowly and their share in the total also continues to be small (Figure 3). The ISO is currently working on a year 2000 version of the quality systems standards. It is very important that firms in the developing countries prepare themselves for the effective implementation of these and in this task the governments of these countries (thorough their institutions on national standards) have an important role to play.



	Jan-93	Jun-94	Dec-95	Dec-96	Dec-97
Developed Countries	26414	66197	118081	144919	191655
Developing Countries	1402	4167	9272	17785	34694
Developing Countries Excluding East Asia	884	2136	3794	6624	10208
Total World	27816	70364	127353	162704	226349

Figure 3: Trends in ISO-9000 certification world-wide, 1987–1997

Source: Mani (2001).

In addition to process or management standards covered by the ISO certification, there are at least three other types of standards: (a) test and measurement standards; (b) product standards; and (c) documentation standards. Firms in developing countries are very often unaware of the plethora of standards that are available. The only way in which

13 ISO is the international organisation for standardization. It is composed of standards institutes from both the developed and developing countries. ISO develops voluntary technical standards, which add value to all types of business operations. Among other things, it facilitates international trade.

they can keep themselves abreast of the latest developments is through governmental standards implementing agencies. This is an area that just cannot be left to the private sector institutions in these countries.

Financial Measures

Tax Incentives

The fiscal measures to promote innovation have assumed much importance in current discussions on innovation policies. Among the fiscal incentives, the most important and widely used instrument is tax incentives. A recent survey by the OECD (1996) has for the first time quantified in an exhaustive manner the entire gamut of public support to manufacturing R&D by the major public players in national R&D systems of the OECD countries. R&D contracts form the most important component, but it has been nearly stagnating. The direct support to R&D is the next important segment and it has been growing at a rate of nearly 9% per annum: the decline in 1993 is perhaps due to reporting gaps. All the three (namely research grants, tax concessions and loan guarantees) put together (research grants, tax incentives and loan guarantees) account for as much as 15% (approximately) of the total industrial R&D budget of the region.

Since direct support to R&D is the one that is relevant for our discussion I now present the details on it. Within the direct support to R&D the share of tax incentives has gone down significantly while that of direct grants has actually increased (Table 9). This shows that in the free market economies, direct grants for specific projects in the private sector are becoming very popular despite the fact that grants may interfere with the market mechanism.

Table 9: Direct Support to R&D in Developed Economies
(Percentage Share)

Financing Instrument	1989	1990	1991	1992	1993
Research Grants	42.5	45.6	45.6	53.5	58.5
Tax Concessions	35.4	31.4	31.10	19.80	19.80
Loan Guarantees	1.2	1.3	1.70	4.6	0.9
Mixed	20.4	21.0	20.5	20.8	19.1
Unclassified	0.50	0.70	1.36	1.40	1.70

Source: Mani (2001)

Among the direct support mechanisms, grants appear to be the most dominant form. In some countries like Israel, for instance, the entire support from government to industry is in the form of direct grants (Mani and Harison, 2000) Moreover, this mode of support has also increased its share rather significantly. Tax concessions, while the second most important, have eroded their share by nearly one-half. This disenchantment as it were with tax concessions warrants a closer look, in particular:

- The specific forms they have taken in various countries; and
- The empirical evidence on their efficacy as a tool for stimulating investments in R&D by private sector firms.

Nature of Tax Subsidies Across Countries

This is based on a survey of tax treatment of R&D expenditure across 20 developed and developing countries.[14] The following stylized facts emerge:

- The majority of the countries covered in the sample allow almost the entire revenue and capital expenditure on R&D to be deducted from the taxable income during a year.
- In some 10% of the countries an amount even greater than what is spent is allowed to be deducted.
- Much of the revenue expenditure deduction is admissible in the first year itself, while much of the capital expenditure deductions is admissible in the first five years.

Nature of Tax Subsidies Across Developing Economies

Among the over 100 or so countries typically referred to as developing, only a handful (approximately 10 or so) have production enterprises that invest in industrial R&D. These countries are either in Asia (specifically in East Asia) or in Latin America. All the developing countries that report sizeable industrial R&D expenditures have some form of tax treatment for R&D, though only Korea and Taiwan among them offer tax credits. Singapore, too, offers some additional tax benefits (Table 10).

Table 10: R&D Tax Treatment across Developing Economies

Country	Definition of R&D for Tax treatment	R&D Depreciation Rate(%)	R&D Capital Depreciation Rate(%)	Tax Credit Rate(%)
Brazil	R&D in computer industry	100	100	none
India	Scientific Research or Know-how	100	100 except land	none

14 These countries include 13 developed countries (Australia, Belgium, Canada, France, Germany, Ireland, Italy, Japan, Netherlands, Spain and Switzerland, UK and USA) and 6 developing countries (Brazil, China, Hong Kong, Korea, Singapore, South Africa and Taiwan).

Korea	Experimental and research expenditure	100	18-20 depreciation; 5-6 for buildings	10 25
Mexico	-	100	3-year SL 20-year buildings	none
Singapore	Either in-house R&D or R&D contracted out to approved organisations excluding social science, quality control, software	100; and in certain cases 200 on application to the Economic Development Board	Depreciation as usual	none
South Africa	Scientific research, development of technology	100 % for revenue expenditure	25	none
Taiwan	Usual	100	Depreciation as usual	15 20
Malaysia	Systematic or intensive study undertaken in the field of science and technology with the object of using the results of the study for the production or improvement of materials, devices,	1. Double deductions on revenue expenditure for approved projects 2. Double deduction on cash contributio n to approved research institutes 3. Double deductions on	Depreciation as usual	none

	products, produce or processes.	payments for the use of the services of R&D centres		

Source: Mani (2001)

Effectiveness of R&D Tax Subsidies

There are two key aspects to evaluating the effectiveness of the R&D tax subsidies. One relates to the efficacy of tax subsidies in general as a policy tool for spurring increased research spending. The other aspect concerns how effective the research and development tax credit in particular has been in stimulating increased R&D spending, and at what cost in forgone federal tax revenues. These issues are analysed in turn.

Direct government funding is apt to be more efficient than *tax incentives* when the policy is to enlarge the stock of basic knowledge available to domestic firms: direct funding would likely raise total spending on basic research by more than the amount spent by the government, whereas one unit of tax incentives would likely yield significantly less than one unit of additional spending on basic research because of its relatively large spillover effects. But if the policy aim is to boost a country's rate of commercialization of new products, processes or services, then a tax incentive has some advantages over direct funding. Success in commercialization hinges on a sound understanding of the market, and tax incentives have the advantage of leaving the decisions of which projects to fund in the hands of private firms rather than government agencies. Even with the tax subsidies, firms will still be putting up most of the money for projects they pursue, which ensures that they, not taxpayers, will bear most of the risks of failure. By contrast, direct funding of commercial R&D could foster a misallocation of resources among major sectors of the economy.

In addition, tax incentives involve less interference in the market and thus allow private sector decision makers to retain autonomy in devising their R&D strategies in response to market signals. It is further opined that tax incentives are easier to administer and are less discretionary than direct project subsidies which are often granted on a case-by-case basis. Project grants are also less predictable as they are subject to yearly budget allocations.

Tax incentives also have a number of limitations. The most important ones are: The R&D tax subsidies tend to operate as entitlement: all firms that qualify may claim it. In addition, a credit is easy to abuse by classifying routine research expenses as innovative ones. Tax incentives are blunt instruments: a tax incentive like a credit cannot be targeted at R&D projects with large spillover effects, unlike direct funding programmes. The propensity to relabel routine expenditures such as quality control and testing as R&D expenditure and then claim tax incentives is also very high, especially in the developing country context.

Empirical Evidence on the Efficacy of Tax Incentives

There are two methodologies for empirically testing this proposition. Most or all the studies are based on the Research and Experimentation Tax Credit of the United States:

- The first technique uses the simple survey method of essentially questioning senior R&D managers about their response to changes in the tax incentive system.
- The second technique uses econometric techniques to estimate *the price elasticity of R&D*—the percentage increase in R&D induced by a percentage fall in its cost.

Venture Capital

Another fiscal instrument, which is increasingly gaining currency, is venture capital funds. Venture capital is an equity form of investment in a technology-based firm at its early stage of development. In addition to providing much-needed risk capital, the venture capitalist also renders a fair amount of *value added* support to the investee. Thus in a sense the venture capital institutions, theoretically speaking, are a solution to financial barriers to innovations in both developed and developing countries. This point is further elaborated in Mani (1997). It is interesting to note that even in many OECD countries, governments have implemented their own programmes to mobilize venture capital in support of small, innovative firms. Direct measures refer to specific publicly funded schemes, which increase the supply of venture capital financing.

The diverse forms of public policy instruments aimed at stimulating the supply of venture capital in OECD countries can be grouped into three main categories: (1) direct supply of venture capital to venture capital funds or small firms; (2) financial incentives to investing in venture capital funds or small firms; and (3) investor regulations determining the types of investors in venture capital. By contrast, most developing countries do not have any policies for addressing the financial barriers to innovation. Even the developing countries such as India that have sizeable venture capital institutions, do not see these institutions as a real solution to the financial barrier to innovations (Mani, 1997).

There is thus a case for incorporating the supply of risk capital as part of public innovation policies. An important point to be noted, however, is that the idea of the venture capital funds is not freely transferable to most developing countries as some of the requisite institutions, such as a vibrant secondary equity market (which would provide a means of exiting for the venture capitalist), are virtually absent in these countries. If the absence of these secondary equity markets is the result of structural weaknesses in the domestic capital markets, then one needs policies to remedy this lacuna before even attempting to establish venture capital institutions.

A Proposed Innovation Policy Framework

I now conclude my discussion of innovation policies by drawing up a hypothetical sequencing of the various components of innovation policy, especially in the context of the majority of the developing countries, which fall in the Type 2 group of assemblers of imported technologies. The sequence is outlined in Figure 4. The first and foremost component is a policy on improving both the quality and the quantity of the human resource, which then leads to the creation of a pool of techno-entrepreneurs. Time again it has been demonstrated that fiscal benefits can lead to meaningful results only in cases where there is an adequate and appropriately skilled workforce. To achieve this, the state will have to tone up its entire education system—primary, secondary and tertiary—and in some cases allowance will have to be made for the importation of skilled persons from abroad in areas where such shortages are badly felt. This last is of course a politically sensitive issue and can be used only as a short-term measure. Once the state has created a critical mass of technically trained personnel, they then must be encouraged with financial measures to establish small and medium enterprises. The success of the research grant system in Israel (Mani and Harison, 2000) and the significant increase in the number of technology-based small and medium enterprises, as well as the increased investments in R&D in Singapore (Mani, 2000) is an eloquent testimony to this line of reasoning.

Innovation Policy

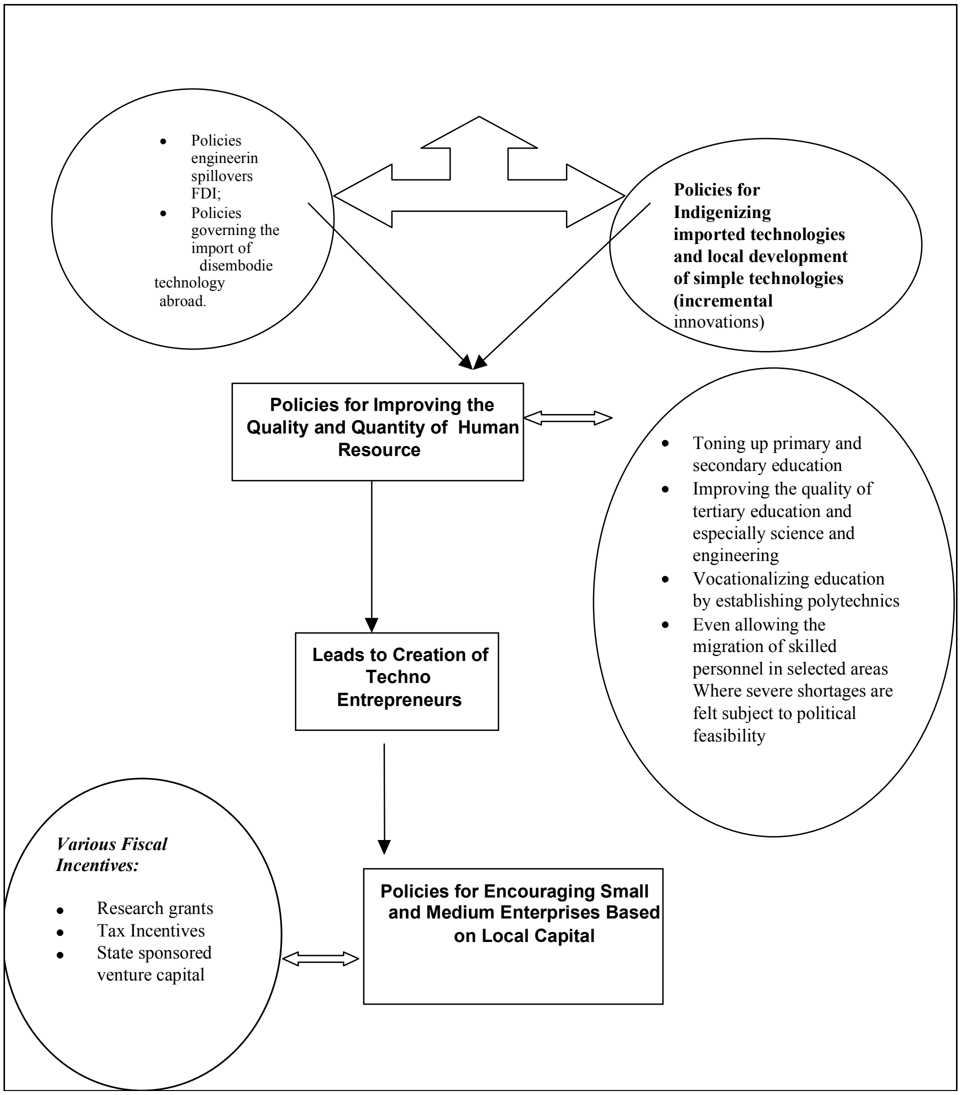


Figure 4: Hypothetical Sequencing of Innovation Policy in a Typical Developing Country belonging to Type 2

Conclusions

It is seen that globalization of innovation is a process restricted, by and large, to the first world. Moreover the market for technologies appears to grow smaller and smaller while non-market forms such as FDI are on the increase. The empirical evidence that there are positive spillovers to domestic firms from FDI is scanty and exists only under certain conditions. However, the example of Singapore shows that spillovers can be engineered through imaginative industrial and innovation policies. Given this state of affairs, it is imperative that developing countries, especially those that who continue to be assemblers of borrowed technologies, must put in place a set of innovation policies to hasten the process of domestic technology development. Central to such a policy framework is the systematic improvement of both the quality and the quantity of technical skill endowments of the domestic human resource.

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