United Nations Conference on Trade and Development

World Investment Report

2005 Transnational Corporations and the Internationalization of R&D

CHAPTER VII
THE ROLE OF NATIONAL POLICIES

United Nations
New York and Geneva, 2005

CHAPTER VII

THE ROLE OF NATIONAL POLICIES

A. Coherent policies and institutions make a difference

The new trend towards the internationalization of R&D outside the Triad implies new opportunities for developing countries to connect with the R&D networks of TNCs. However, to date most developing countries remain excluded from these networks. Thus the technological and innovative capability gap between this latter group of countries and other economies continues to widen. The challenge is to narrow this gap.

The experience of those developing countries that have tapped into the TNC knowledge networks shows that policies and institutions are very important in TNCs' decisions on where to locate their R&D. Investment in R&D is attracted more to "created assets" than "inherited endowments", which means that it is possible for governments to influence the outcome of this decision-making process. This chapter discusses how host countries can enhance their ability to benefit from R&D internationalization by TNCs. Chapter VIII considers the international framework for rule-making in this area.

The development of innovative capabilities lies at the heart of economic growth and development (chapter III). While the precise interrelationship between technology and economic growth is open to debate, few, if any, countries have succeeded in achieving and sustaining high growth levels without investing in and exploiting technology. The promotion of innovation, with R&D being an integral part of innovative activity, is consequently becoming a policy priority in countries at all levels of development.

The globalization process makes this even more important. A freer flow of goods, services, capital and labour adds competitive pressure on firms — be they large or small, local or transnational. Innovation is essential if firms are to use new technologies efficiently and stay competitive in such an environment.

The ability of companies to innovate is intrinsically linked to the environment in which they operate. A useful framework for assessing the role of policies in facilitating innovation is the national innovation system (NIS) (chapter VI). An understanding of the NIS helps policymakers identify ways to enhance innovative performance and assist in pinpointing mismatches within the system, both among institutions and in relation to government policies (OECD 1997b). Proper institutions – interpreted broadly to cover organizations and the rules and incentive structures governing innovation — are crucial to the effective functioning of an NIS (North 1990, Metcalfe 1995, Edquist 1997).

Key policy objectives include providing an institutional setting that encourages and rewards innovation and strengthens innovative capabilities in domestic enterprises and technology institutions. The ability to make commercial use of results generated by R&D — by firms, universities or government agencies — depends on factors that can be influenced by government action, such as the skills of the work force, incentives for entrepreneurship and risk-taking, the quality of public institutions, access to venture capital, trade and competition policies and governance structures (Andersson 2005). In addition, governments can take measures to foster interaction among the various actors in the NIS.

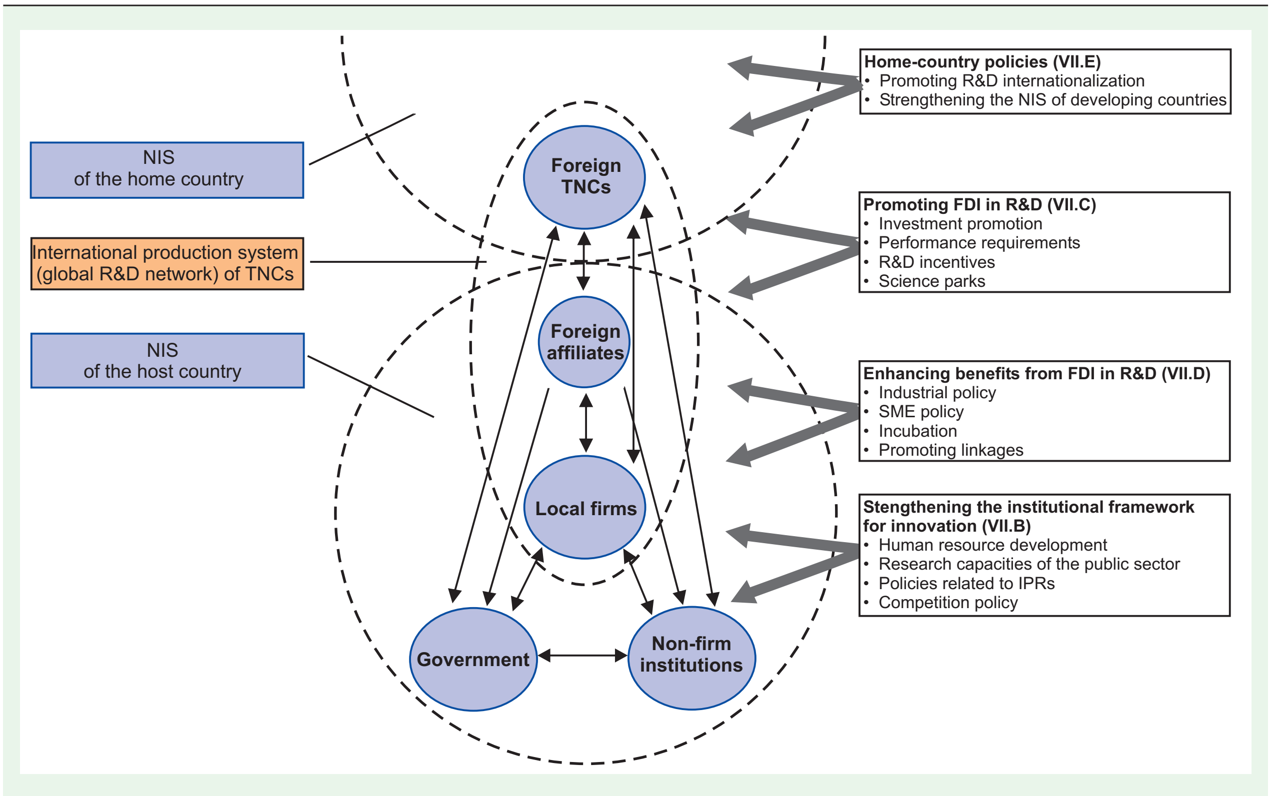
As depicted in figure VII.1, various policy and institutional areas need to be addressed to maximize the benefits that can be obtained from

R&D internationalization. The starting point is to build an institutional framework that fosters innovation. Particular policy attention is needed in four areas: the availability, cost and quality of human resources; the role of public research; intellectual property rights (IPRs); and competition policy. Efforts in these areas need to reflect the comparative advantage and technological specialization of each country as well as the development trajectory along which a country plans to move. FDI policy is also vital to promote desired forms and impacts from FDI. Selective policies in this area include targeted investment promotion, performance requirements and incentives, and science and technology parks. Finally, governments need to pay attention to boosting the capabilities of the domestic enterprise sector, notably through industry-specific policies and those relating to small and medium-sized enterprises (SMEs). It is of course also important to ensure political and macro-economic stability and the proper functioning of financial markets, but these aspects are beyond the scope of this analysis.

While the long-term goals are similar, countries at different levels of development and with different industrial structures have different policy priorities. Throughout, this analysis seeks to draw lessons from countries — notably in East and South-East Asia — that have successfully managed to develop their innovation capabilities, sometimes, but by no means always, involving TNCs in the process.

The chapter is structured as follows. Section B considers key policy areas that need to be addressed to strengthen the institutional framework for fostering innovation with the involvement of TNCs, taking into account the different comparative advantages and development strategies of countries. Section C addresses the role of FDI policies, and section D discusses industry-specific policies and SME policies for enhancing the benefits of R&D internationalization by TNCs. Section E considers the role of home countries in enhancing the ability of host countries to benefit from the internationalization of R&D by TNCs. Section F concludes.

Figure VII.1. National innovation systems and FDI in R&D: the policy dimension



Source: UNCTAD, adapted from Liang 2004, p. 171.

B. Strengthening the institutional framework for innovation

The policy agenda for promoting benefits from R&D internationalization is wide. This section discusses four areas that are critical for strengthening the institutional framework and the functioning of the NIS: human resources, public R&D, the protection of IPRs and competition policy.

1. Fostering human resources

The critical importance of human resources for development is widely accepted. For example, a common denominator of the economic success of the various economies of East Asia is a strong emphasis on human capital at all levels (e.g. World Bank 1993). This applies directly to policies concerning R&D internationalization. Company surveys show that access to skills is an overriding concern for most TNCs in deciding where to locate their R&D. As noted above (chapter V), the expansion of R&D in developing countries – although still limited – is heavily influenced by the availability of knowledge workers. The improved supply of highly skilled people is occurring as a result of deliberate and long-term policies to raise educational standards, particularly at the tertiary level, as well as from efforts to attract human resources from abroad. While education is important at all levels – from primary to tertiary – the discussion below focuses on higher education.

a. Development of skilled human resources

Not all innovation requires people with a university education. Many important inventions have been produced by people with limited formal education. However, for R&D in large private organizations such as TNCs, which seek a stream of incremental improvements in addition to new inventions, there is a clear need for technical and scientific skills developed through higher education (Baumol 2004). Moreover, the growing science base of many new industrial technologies makes it more difficult for the "gifted amateur" to innovate. To the extent that countries aspire to attract TNCs' R&D, the development of relevant domestic skills and capabilities is thus crucial. For countries that are currently in a weak position to attract such R&D, skills development is even more relevant to boost domestic capabilities.

In the past decade or so a few countries in developing Asia, but also some other economies, have emerged as large sources of workers with tertiary education, and this trend is set to continue (chapter V). This is particularly visible in technical skills like science, engineering, mathematics and computing. China, India and the Russian Federation together accounted for almost a third of all tertiary-level technical students in the world in 2000/01.

While the number of qualified engineers and scientists clearly plays an important role in attracting R&D by TNCs, their quality and specialization also matter. The skills required for applied research in pharmaceuticals and biotechnology are, for example, different from those required in automotive design. Similarly, the needs differ between different stages of economic development. Policy-makers have to ensure that the education system delivers the kind of skills that are the most in demand. Thus, efforts in the education area need to be closely coordinated with policies in other fields. For example, the development of technical capabilities in the enterprise sector is important to create local demand for university graduates. Without such demand, there is an increasing risk of people with higher education migrating to other countries in search of job opportunities.[1] In this context, foreign affiliates can help by providing new job opportunities (chapter VI).

One way to address this challenge is to use the State as a "skills coordinator" (Green et al. 1999). To accelerate skills formation in relevant areas, governments need an informed view of the skills that are in demand. Asia offers significant lessons. In Singapore, for example, the Ministry of Trade and Industry, the Economic Development Board and the Council for Professional and Technical Education work closely together to monitor future skills needs, drawing on inputs from foreign and local investors as well as from education and training institutions. This information is matched against national policy objectives and used to build targets for various components of universities, polytechnics, schools and the Institute for Technical Education (Green et al. 1999, p. 88).

In Latin America, the private sector has expressed concern that the skills generated by universities do not match its needs (Freeman

1995, de Ferranti et al. 2003, p. 228). Two out of three LAC researchers work in the public sector, mostly in universities, and only one in ten are employed in the business sector. Except for Costa Rica — where around 25% of researchers are working in the business sector — that figure does not exceed 12% in any LAC country. In terms of R&D spending, development work (as opposed to basic or applied research) accounts for less than 30% in LAC as compared with more than 60% in countries like the Republic of Korea or the United States (Velho 2004, p. 17). Thus there appears to be a misalignment between the policies taken to promote skills and the demand from the private sector, partly reflecting the current industrial specialization towards natural resources and assembly operations based on low labour costs:

> "Latin American and Caribbean production patterns on the one hand induce private sector and enterprises to express a meagre demand for knowledge and on the other hand lead domestic agents to mostly seek outward oriented linkages and coordination, basically privileging foreign companies and research laboratories that already have sound reputation and worldwide widely recognized experience in effective and efficient science and technology efforts. Thus a mismatch ensues between demand side needs and supply side offering, hampering policies' impact " (Cimoli et al. 2004, p. 11).

Education policies also need to evolve over time as the demands from industry change and countries develop. The case of the Republic of Korea is illustrative. In the 1960s, a system of technical training was set up as part of broader efforts to improve the infrastructure for science and technology. In the 1970s, the Government placed emphasis on technical and engineering education in the fields of heavy and chemical industries. In the 1980s focus shifted towards the technology-intensive industries and greater efforts were made to bring back Korean scientists working overseas. Since 1990 more attention has been given to promoting creativity, with the setting up of the Creative Research Initiative in 1997 to encourage a move from "imitation" to "innovation". More recently, special incentives have been offered for universities to become less teaching-oriented and more research-oriented.

It is important not just to educate people but also to ensure that their skills are updated continuously. This is especially true when there is a mismatch between the supply and demand of specialized skills. Policies involving all stakeholders can help mitigate such problems if all relevant actors recognize and accept the need for actual implementation of specific policy changes (Vertzberger 2005, pp. 24-25). Policy intervention may be needed to re-skill and re-train production workers, technicians and engineers, expand the numbers of graduates with skills in special demand in industry,[2] emphasize the training of experienced managers, encourage entrepreneurs to upgrade their strategic capabilities and align incentives for universities to interact with the private sector (e.g. through internships and sabbaticals).

Countries can involve foreign affiliates in this process, for example by encouraging them to participate in joint projects with universities and other training institutions. This can be done at different levels of education and training. Costa Rica, for example, attracted a major semiconductor investment from Intel in 1996. Close links between Intel and the Instituto Tecnológico de Costa Rica helped secure financial support from Intel to develop new programmes and increase enrolments of engineering students (Mytelka and Barclay 2004). The auto parts maker Delphi collaborates with the privately-run Tec de Monterrey in Mexico to ensure adequate skills for its development work in Ciudad Juarez.[3] In India, Motorola works with the Pune Institute of Advanced Technologies to offer a postgraduate degree in advanced telecommunications engineering with a software focus (Reddy 2000). In Singapore, the efforts of the Economic Development Board to involve TNCs and foreign governments in training programmes helped ensure that they were relevant and up to date (box VII.1). Without these efforts the Board's investment promotion activities and subsequent upgrading into more advanced activities would have been crippled (Low et al. 1993, chapter 7).[4]

b. Importing human resources

Few countries can create all the skills they need; they therefore make use of a number of expatriate skills. In the OECD as a whole, some 1.9 million students are enrolled in tertiary education outside their country of origin (OECD

Box VII.1. Engaging foreign affiliates in training: the Singapore case

In 1970 Singapore faced a serious and unexpected shortage of welders due to the rapid expansion of its ship-repair industry.[a] The Government addressed this problem partly by expanding specially designed courses for the training of welders, and also by launching policies to anticipate future needs for industrial skills (Low et al. 1993). A number of joint industrial training programmes by the Economic Development Board (EDB) and leading TNCs were established: the Tata-Government Training Centre (in 1972), the Rollei-Government Training Centre (1973)[b] and the Philips-Government Training Centre (1975).

The training programmes, with annual intakes of up to 100 people, were designed by the TNCs involved, which also managed the operations through seconded directors and experts. All the programmes required in-plant training in the TNC factories after completion of two years of in-centre training. Vocational institutes subsequently adopted many of the courses and curricula. The EDB offered incentives (e.g. land and buildings and cost sharing) to induce TNCs to participate. It also launched a scheme that required trainees to work in the TNC for a number of years after the training, thereby assuring the TNCs a secure supply of skilled craftsmen. While these institutes did not engage directly in innovation or R&D, they contributed to the development of innovative capabilities in Singapore.

The model of joint training institutions was subsequently refined, involving not only TNCs but also foreign governments or government agencies. Between 1979 and 1982 the Japan-Singapore Technical Institute, the German-Singapore Institute and the French-Singapore Institute were started. In the mid-1980s a "transnational" approach was adopted, in which resources and expertise were sourced from more than one country.[c] The contributions of the TNCs took various forms (Low et al. 1993):

- Transfer of technology and know-how through secondment of experts;
- Training of EDB instructors and technical staff at the participating firms' overseas locations;
- Assistance in curriculum and programme development;
- Donation and/or loan of equipment by the participating firms;
- Commitment by the participating firms to upgrade equipment and software; and
- Commitment to participate for a minimum duration of three years, subject to review and extension.

Source: UNCTAD.

[a] The shortage was a consequence of the closure of the Suez Canal, and the rapid growth of offshore oil exploration in South-East Asia. The demand for welders was further fuelled by the construction of new oil refineries and the expansion of existing refineries.

[b] In 1982 this became the Brown Boveri-Government Training Centre following the failure of Rollei Werke.

[c] For example, the German-Singapore Institute attracted the participation of several TNCs from the United States (e.g. Hewlett-Packard), Europe (e.g. Siemens, Bull, Asea, Zeiss) and Japan (e.g. Seiko, Matsushita). The Brown Boveri-Government Training Centre was transformed into the Precision Engineering Institute in 1988, which oversees a number of laboratories and manufacturing units (such as the Siemens-Nixdorf-EDB Centre for Advanced Tool and Die Making and the Japan-EDB Computer Numerical Control Laboratory).

2004c, chart 3.6). The United States has been the main recipient of global knowledge migration in recent decades. At the end of the 1990s over 50% of the post-doctoral students at MIT and Stanford were foreign citizens and more than 30% of computer professionals in Silicon Valley had been born abroad.[5] In Europe the growing importance of the knowledge society and an aging population has made the attraction and retention of talent a key priority within the Lisbon agenda (European Commission 2004, p. 20). Also at the national level, many European countries have taken steps to attract foreign skills. For example, the Government of France in 2004 launched a programme to attract the world's leading experts to growth sectors and to build teams around them (*WIR04*, p. 87); Belgium, Denmark, Finland, France, the Netherlands and Sweden have introduced special tax rules for foreign experts; and Germany and the United Kingdom have established special programmes to facilitate easier migration of foreign experts.[6]

Several developing countries are also seeking to attract foreign expertise. Singapore has a liberal immigration policy to attract highly skilled people to private firms and public research institutes. By 2003, almost a third of doctorate level research and engineering scientists in the tertiary and public research institutions in Singapore were non-citizens.[7] Such migration contributed to Singapore having the 7th highest ratio of researchers per million inhabitants in the world, just below that of the United States and ahead of countries such as France, Germany and the United Kingdom. Singapore is spending almost $2 billion to recruit leading foreign scientists to develop research in the areas of biotechnology, genomics and nanotechnology.[8]

Many cities in China are actively seeking to attract highly skilled people in the large diaspora. For example, Shanghai is one of the most R&D-intensive areas of China. In 2002 the Shanghai government announced a series of measures, such as a preferential residential policy and a number of financial incentives, to attract university graduates from elsewhere (Chen 2004, pp. 29-30). The Republic of Korea has not relied much on skills immigration although various efforts have been made to increase the return of Korean scientists working abroad (box VII.2).[9]

Box VII.2. Policies in the Republic of Korea to attract back scientists in the diaspora

In the 1960s the Republic of Korea initiated a project to recruit Korean scientists working abroad to meet the demand for human resources in science and technology. These efforts began with the establishment of the Korea Institute of Science and Technology in 1966, and in 1968 a specific project was launched to attract back qualified scientists in the diaspora. As inducement measures they were offered modern laboratories, competitive salaries and autonomy in their research. From 1968 to 1979, 238 scientists returned to stay permanently in the country and another 255 scientists returned temporarily. These people played an important role in the 1970s and 1980s and contributed to cultivating new human resources in R&D. In 1994 the work to attract qualified Korean scientists from abroad was absorbed into a new "Invitation Program for Foreign Scientists & Engineers".

Source: UNCTAD, based on Cho 2002.

What are the implications of the increased mobility of highly skilled workers for the strength of the NIS of a country? On the one hand, it may accentuate the brain drain from some developing economies, aggravating an already limited supply of skilled human resources. Up to a third of R&D professionals from developing countries reside in the OECD area.[10] On the other hand the diaspora is a potential source of skills, entrepreneurship, knowledge and capital for the home countries. Bangalore in India has some 35,000 "returned non-resident Indians", many with training and work experience in the United States.[11] While some of these returnees join foreign affiliates, others have set up new technology-intensive businesses in India (see also chapter VI). To the extent that countries can create conditions that are conducive to such return flows of human resources, the original brain drain can be turned into brain circulation with positive implications for the NIS.

2. The role of research capabilities in the public sector

The public sector assumes an important role in every NIS, but notably in the area of basic research. In many developing countries, public universities and research institutes even account for the bulk of R&D (chapter III), but such efforts are too often de-linked from the enterprise sector. For public R&D to provide spillovers and help kick-start innovation by enterprises it is essential that enterprise R&D links with public R&D efforts, and that the public research institutes promote the spin-off of new companies.

Public research institutes can perform three important functions within the NIS (Patel and Pavitt 1994): undertake basic research and engineering/development work and produce new knowledge, some of which may be patentable; provide technical services (e.g. testing, consultancy) for firms as part of the infrastructure for metrology, standards, testing and quality (MSTQ); and provide training to researchers. As countries develop, the nature of the work undertaken in public research institutes tends to become more sophisticated. In the most developed countries, universities and other public research institutes assume key roles especially in the area of basic research. In general, public R&D funding has played a more important role in East Asia than in developed countries in helping to develop innovative capabilities in key technological industries (Hu and Mathews 2003). The Industrial Technology Research Institute in Taiwan Province of China is a good illustration of the role that public research institutes can play (box VII.3).

However, linkages between universities, public research institutes and enterprise R&D are often weak (e.g. Ernst and Mowery 2004). This is a common situation in African countries. A study covering four African countries found hardly any interaction between universities and the private sector (Lall and Pietrobelli 2002). Moreover, the establishment of specialized R&D institutes in Africa with the aim of supporting firms in agriculture or manufacturing has produced meagre results (Adeboye 1997, Oyelaran-Oyeyinka 2004a). Public R&D activities tend to be insufficiently oriented towards serving the needs of private-sector clients, and industrial stakeholders are often unaware of the new technologies developed (Lewanika 2005). This failure has been explained by the lack of an institutional base for innovation, a shortage of appropriate human capital, and the inability to tailor the activities of the institutes to the local context (Oyelaran-Oyeyinka 2004a).

In LAC, many public research institutes have been in existence for many decades, mainly dealing with natural resources and health (Velho 2004). There are also many industrial technology institutes and some R&D institutes that focus specifically on oil, telecoms, electricity and space. However, in many instances their work has not benefited the private sector directly. While the performance of the institutes varies, a common problem is that their researchers have limited knowledge and understanding of the specific needs of the private sector. To some extent this reflects the weak incentives provided to their researchers to interact with the private sector (de Ferranti et al. 2003, p. 224; Cimoli et al. 2004). After the economic crisis in the 1980s, however, public research institutes in many LAC countries were required to increase their sourcing of funds from the private sector. As a consequence, where stronger links with the private sector emerged, institutes also began to conduct R&D that was more relevant to industry (Velho 2004).

It is possible to increase the relevance of public research institutes to the private sector. India has a network of 38 laboratories and 45 field/extension centres under the Council of Scientific and Industrial Research (CSIR), employing over 4,600 active scientists. In order to revamp a system that had till then produced little that was of technological benefit to industry, the Government in the late 1980s launched a major reform programme.[12] It decided to limit the level of public financing of the laboratories, and set a target for CSIR to earn 40% of its expenditures by selling research and other services to industry. The new annual budget of each laboratory was determined by its revenues earning capability. As a result, the institutes'

Box VII.3. Spurring innovation in Taiwan Province of China

A well-known public research institute that has had a strong impact on innovation capabilities is the Industrial Technology Research Institute (ITRI) in Taiwan Province of China. Established in 1973 as a non-profit R&D organization, ITRI was instrumental in establishing the integrated circuit industry in Taiwan Province of China in the 1970s by licensing fabrication technology from RCA and transferring it to local companies. Its subsidiary, the Electronics Research and Service Organisation, was also instrumental in 1984 in helping Acer develop what became the first 16-bit IBM-compatible personal computer from Taiwan Province of China (Amsden and Chu 2003).

According to ITRI's president in an interview in 1996, ITRI's unique role was to train professionals and then spin them off and encourage them to go into industry. Almost 10,000 people have been trained at ITRI over the past 20 years of which 73% joined industry. ITRI was able to replace them by recruiting new graduates from universities and expatriates from the United States. Personnel trained by ITRI made up the backbone of the R&D and engineering workforce in the Taiwanese IT industry on an ongoing basis, together with the overseas Chinese returning to Taiwan Province of China with technical and managerial experience from companies and universities in the United States (Kim and Tunzelmann 1998).

Source: UNCTAD.

earnings almost tripled between 1992 and 1997 to reach 2.1 billion rupees in 1996/97.[13] By 2005, CSIR accounted for around 25% of all patents filed in India by Indians and a significant share of all patents assigned by the USPTO to Indian institutions (chapter IV).[14]

Thus, while the building of innovative skills in the public sector initially may be costly, it can provide vital resources for technological development if enterprise R&D grows and establishes close links with public R&D. Institutes that have strong ties with the domestic private sector may also become partners with foreign affiliates. Foreign affiliates can interact with the institutes in three main ways: by subcontracting services to them; by undertaking joint research projects or programmes; and by employing skilled people from the institutes. Government-supported research institutes in the Republic of Korea play an important role in this regard, a role that has evolved over time (box VII.4). In light of the internationalization of R&D, there is a growing need to explore various international dimensions of university-industry linkages. Specifically, further analysis is warranted of the role of TNCs as collaborators with national universities in developing countries and of possible new avenues for the international exchange of scarce human resources (Ernst and Mowery 2004).

Box VII.4. Government-supported research institutes in the Republic of Korea

In the early stages of economic development, the Republic of Korea, lacking indigenous technological capability, had to rely on foreign sources for technologies required for industrialization. With a view to developing the absorptive capabilities of the country, in 1966 the Government established the Korea Institute of Science and Technology (KIST). KIST's R&D activities were initially directed towards finding solutions for simple and practical problems arising from the application of the imported technology.

In the 1970s the Government created specific R&D organizations in strategic fields such as electronics, telecommunications, machinery and metals, shipbuilding and chemicals to support industrial development. These institutes have been making important contributions to building an indigenous R&D base.

As private R&D expanded, changes were needed in the role, operational efficiency and research performance of the institutes. In response, the "Law for the Establishment, Operation and Development of GRIs", enacted in January 1999, paved the way for the creation of five research councils to oversee the operation of the research institutes.[a] The councils were placed directly under the Prime Minister's Office, and individual institutes were given more autonomy and responsibility. The changes were expected to improve research productivity, strengthen linkages between institutes, and increase the transfer and commercialization of research results. As of June 2005 there were 31 government-sponsored research institutes in the country.[b]

The institutes actively interact with foreign research institutes and with TNCs. For example:

- The Paris-based Pasteur Institute set up a branch in KIST in April 2004. A joint project costing 146 million will initially focus on malaria, tuberculosis and cancer research.
- Intel opened a research centre in Seoul in 2004 to develop the next platform for state-of-the-art wireless communications technology and multimedia compression technology. The centre will also collaborate with the Electronics and Telecommunications Research Institute.
- The Korea Advanced Institute of Science and Technology and the Cavendish Laboratory of Cambridge University opened a joint research centre in Daejeon City in November 2004. It will focus on nanoelectronics, fibre-optic electronics and biophysics.

Source: UNCTAD, based on Republic of Korea, Ministry of Science and Technology 2003a.

[a] These five research councils are: the Korea Research Council of Fundamental Science and Technology (S&T); the Korea Research Council of Industrial S&T; the Korea Research Council of Public S&T; the Korea Council of Economic and Social Research Institutes; and the Korea Council of Humanities and Social Research Institutes.

[b] In 2004, the three S&T-related councils were placed directly under the Deputy Prime Minister of Science and Technology.

3. Policies related to intellectual property

A well-defined, balanced and enforceable system of IPRs is an important part of the NIS, especially in countries which have fairly well developed innovative capabilities. By assigning ownership to knowledge assets it creates incentives for knowledge generation and facilitates commercial exchange. It can also assist in protecting the interests of a host country's firms and institutions in making sure that they are adequately rewarded in R&D collaborations with TNCs (chapter VI). All members of the WTO are now required to meet minimum standards of IPR protection as set out in the Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS) (chapter VIII; UNCTAD and ICTSD 2005). Thus the prime issue is how to implement an IPR regime that helps create an environment conducive to innovative activities and maximize the benefits of the country's knowledge assets, including in the context of the R&D internationalization by TNCs.

The main areas of intellectual property include copyright, geographical indications, patents, trademarks and undisclosed information (including trade secrets).[15] For R&D — and innovation in general — the most relevant types are patents and trade secrets.[16] Trade secrets may in fact be even more important than patents for a country to be able to attract FDI in R&D. To the extent that the R&D process involves sensitive information, TNCs will always seek to protect trade secrets against disclosure. A 1994 survey of 1,478 R&D labs in the United States manufacturing sector found that trade secrecy was effective for 51% of innovations, while the corresponding figure for patents was only 35% (Cohen et al. 2000).

As noted in chapter V, the importance of IPR protection for attracting R&D-related FDI is mixed and varies by industry (box V.3). Developing countries could increase their attractiveness as locations for conducting R&D by strengthening their protection of intellectual property, but it is not necessarily considered a prerequisite in the decision-making process of TNCs. Other factors, such as the availability of human resources, infrastructure and the domestic innovative capacity in general, appear to be more important. However, the development of domestic innovative capacity, which does affect TNCs' location decisions, is partly influenced by the IPR regime. Furthermore, to the extent that such a regime facilitates sharing of knowledge and learning, it can also help enhance the benefits of FDI in R&D.

At the same time, IPR protection — especially a system of patents — may also entail costs. It may, for example, place excessive burdens on consumers. IPR protection assigns the owner of intellectual property a degree of monopoly power. In order to balance the interests of producers and consumers, countries therefore need to complement the introduction of IPR regimes with adequate competition policies (section B.4).

If well implemented, an IPR regime can help address the risk of negative effects from R&D activities of TNCs (chapter VI). While collaboration in R&D between TNCs and local R&D institutions can be beneficial to the host economy by transferring tacit knowledge to the host country, there are also potential pitfalls. Typical university–industry collaboration takes the form of the outsourcing of a research project to a university by a TNC. The latter may provide funding in exchange for the legal ownership of the research outcome, including the right to patent it. If well designed and effectively implemented, an IPR system may help protect the local partners against unfair compensation for their contributions (chapter VI).

Another example of the misappropriation of knowledge assets in developing countries is related to traditional knowledge.[17] This broadly refers to the cumulative dynamic body of knowledge, much of which is related to the natural environment, held by an indigenous or local community that has been handed down through generations by oral transmission. There are two main issues of concern. First, indigenous communities that are holders of traditional knowledge should be able to maintain their way of life. Second, if commercialization based on their knowledge assets were to yield profits, the indigenous communities should be appropriately compensated. Governments or communities may take measures to safeguard against the possibility of others taking IPRs illegitimately.

One approach is to publish the details of the traditional knowledge before anyone tries to patent it. This can be useful for traditional knowledge that is clearly in the public domain and that entered the public domain with the free and informed consent of the owners of this knowledge (which is often not the case). This approach has some limitations, however, including the fact that it puts the burden of publication fully on generally poor local and indigenous communities. Moreover, as it increases public access to the knowledge, without proper safeguards the possibility of its unauthorized commercial use increases.

Furthermore, governments may consider establishing a legal framework that gives holders of traditional knowledge the right to take action against misuse or false claims in this area. Ascertaining whether the knowledge was accessed from the community with its free prior informed consent and in accordance with its customary laws could be one component.

Given that traditional knowledge has long been used by indigenous communities, it may be hard to claim that products based on traditional knowledge are "novel" or involve "inventive steps", which opens the way for legal challenges against such patents. In March 2005 the world's first legal challenge to a patent drawing on traditional knowledge was concluded in favour of the challenger. In 1994, a patent on the method for controlling fungi using extracts from the Neem tree — a tree indigenous to the Indian subcontinent — was granted to the United States Government and a United States-based TNC, W.R. Grace.[18] However, a legal opposition to this patent was subsequently filed, and after a process lasting ten years the European Patent Office eventually revoked the patent.[19] It is worth pointing out that actions to revoke inappropriate patents are costly, no financial compensation is provided to those opposing the patent to cover these costs.

Apart from establishing a legal framework for IPRs it is clear that many developing countries need to build the capacity for its implementation — including an efficient patent office and judicial system. In addition to knowledge of the legal system, a considerable degree of expertise in science and technology is required for examining patent applications and claims of infringement.[20] In designing the IPR policy governments need to take into account their countries' economic needs as well as their capacity for implementation.

In this area there is need for additional technical assistance and capacity building. Although several initiatives exist to assist developing countries in implementing the TRIPS Agreement (chapter VIII), a significant gap remains between the development of legal systems and their enforcement and management. Additional technical assistance may be required to help developing countries to:

- Manage and assess the value of their knowledge resources;
- Integrate IPR systems in their national development strategies;
- Assess the performance and adequacy of their IPR systems; and
- Develop and implement IPR systems to promote R&D collaboration with TNCs. This involves an improved understanding of licensing agreements and the interface between IPRs and competition law and policy.

Such assistance could also aim at strengthening the capacities of entrepreneurs and governments to negotiate contracts and other conditions or clauses for the transfer of technology and IPR protection, either as providers or as receivers (UNCTAD 1996a, p. 4).

4. Competition policy and innovation

Competition policy can play an important role in complementing the institutional framework for ensuring that a country's NIS is conducive to innovation, and that the benefits from TNCs' R&D are maximized while potential costs are minimized. Competition policy is not a proactive tool in encouraging FDI in R&D, but it can help boost innovation by maintaining and promoting a competitive environment. Competition provides a general incentive for firms — be they foreign or local — to innovate, for example, by encouraging them to invest in R&D and other innovatory activities (Nickell 1996, Boone 2001).[21] At the industry level, a key determinant of R&D intensity is the extent to which the local institutional context rewards innovation (Furman et al. 2002). This depends on many factors, including the IPR regime at the national level, as well as industry-specific factors such as government regulations, pressure from local rivals and openness to international competition (Sakakibara and Porter 2000).[22]

The relationship between competition and innovation is complex. Although the traditional literature on industrial organization predicts a positive correlation between market concentration and innovation,[23] empirical work has shown a positive correlation between the level of competition and innovative output (Geroski 1994, Blundell et al. 1999).[24] This is particularly evident in developing countries and transition economies, where firms that face greater pressure, especially from TNCs, are more innovative than firms that feel less pressure (Carlin et al. 2001, World Bank 2004). Recent work has shown that stricter competition laws and better enforcement of those laws have a positive impact on innovation in low- and middle-income countries (Clarke 2005).

It is now commonly accepted that competition policy needs to move beyond its traditional focus on static efficiency (Ordover and Baumol 1988).[25] It should *inter alia* seek to evaluate the effects of business practices on innovation and assess potential trade-offs between dynamic and static benefits. Firms do not innovate in isolation; close interaction with customers, competitors and suppliers is required for the innovation process to take off.[26] Finding the right combination of competition and interaction is therefore crucial (Wald and Feinstein 2004). Such considerations become even more important when FDI enters the picture.

For promoting greater benefits from R&D internationalization by TNCs, some applications of competition policy are particularly relevant such as the licensing of IPRs, collaboration through joint ventures and alliances in high-technology industries, standard setting and patent pools, merger control, and policies to address restrictive business practices. These areas of application all relate to business practices of international scope, and represent the interface between competition policy and R&D by TNCs.

One set of competition policy issues relates to such IPR-related business practices as conditional licences and unconditional refusals to license. Various jurisdictions, especially in developed countries, have introduced guidelines regarding the licensing of IPRs.[27] Specific guidelines have also been issued to tackle competition policy questions arising from various forms of cooperation such as joint ventures, standard-setting and patent pools.[28] In terms of international competition policy enforcement, these regulations may facilitate cross-border collaborative business activities, some of which are associated with R&D-related FDI.

Merger control is another relevant application area. Many firms have internationalized their R&D activities through acquisitions of firms that also conduct R&D. From a host country perspective this may raise concerns that existing R&D activities may be dismantled after the takeover or that strategic technology will be lost (chapter VI). From a wider perspective, mergers between two major players in an industry can have both positive and negative effects on R&D and other innovative activities. On the one hand the combination of two firms' sales and distribution networks may create better conditions for investing in R&D and innovation. On the other hand the merger of two competing firms may result in a stronger (or even dominant) market position for the merged firms, and therefore weaker incentives to innovate. Such concerns may be particularly important in high-technology industries, in which technology changes rapidly and the pressure for innovation is fierce. In the United States, for instance, many more merger challenges were based on innovation concerns during the 1995-1999 period than in the 1990-1994 period (Gilbert and Tom 2001). For developing countries it may be important to implement a more stringent competition policy for dealing with TNCs entering through mergers and acquisitions,[29] giving due consideration to the enhancement of national innovative capacities.

Finally, competition policies need to address possible restrictive business practices by TNCs and their foreign affiliates. A prominent role for foreign affiliates in an NIS implies that a competition authority may have to pay more attention to possible obstacles to market entry facing domestic firms. This is particularly important if foreign companies engage in certain forms of restrictive business practices such as strategic behaviour and vertical restrictions or influencing government policy-making.[30] The latter might lead to regulatory capture, whereby the public authorities involved lose sight of the public interest and protect the privileges of established firms (Stigler 1971, Peltzman 1976). Unrestricted entry of domestic firms is crucial for ensuring the existence of an active and innovative domestic enterprise sector, and thus for reaping benefits from spillovers from TNC R&D. In this regard, competition policy can complement other government efforts in countering TNC restrictions and influencing the formulation of relevant policies, and in safeguarding consumer interests (Liang 2004).

C. Promotion of R&D-related FDI

In the context of reaping benefits from the R&D internationalization by TNCs, FDI policies assume an important role. FDI policies should in principle be derivatives of industrial, regional and science and technology policies. Investment promotion agencies (IPAs) are important in this process, especially if they act in close partnership with other government actors in an NIS. Relevant FDI policies also include the use of performance requirements, incentives and science parks.

1. The role of investment promotion agencies

The appropriate role of an IPA in a country's overall strategy to benefit from R&D internationalization by TNCs depends on several factors, including the country's level of development, comparative advantage, institutional framework and development objectives. An IPA can potentially serve two prime functions. The first is to communicate and market existing investment opportunities, e.g. through targeted promotion. In the specific case of R&D-related FDI, such targeting would have to be based on a careful assessment of the location's strengths and weaknesses, and a good understanding of the locational determinants of potential R&D-related projects.

If a location is unlikely to be able to offer the conditions needed to attract R&D by TNCs, however, the main role of the IPA may not be to actively promote related FDI opportunities but rather to act in its policy advocacy role. IPAs may draw the attention of relevant government bodies to areas that are important for making a location more attractive for knowledge-intensive activities by TNCs. IPAs can potentially serve as a bridge between the private and public sector, helping to improve the understanding of what is required to benefit from R&D by TNCs.

For an IPA to play a constructive and effective role in this regard it needs to be well connected with key government ministries and to have a well-defined mandate to provide policy advice on relevant issues (see box VII.5 for the case of the Czech Republic).[31] In the Republic of Korea, the Government in 2003 set up an IPA, Invest Korea, to promote FDI, including in R&D. In addition, it also established in the same year the Korea Foundation for International Cooperation of Science and Technology (KICOS) to serve as a bridge between domestic and foreign non-profit R&D centres. KICOS focuses on promoting R&D centres involving prestigious foreign research institutions and educational organizations. The two agencies both provide assistance to investors in R&D, as part of the Government's effort to make the Republic of Korea the North-East Asian R&D Hub for the advancement of science and technology.[32]

Preceding chapters have shown that a significant presence of production activities can be an asset when countries seek to develop R&D activities in an industry. The experiences of some Asian countries in the case of electronics and semiconductors, and Brazil in automotive, are examples from developing countries. From the perspective of investment promotion, this makes the role of after-care services potentially important. Indeed, in many countries the greatest potential for R&D investment by TNCs is likely to be found among already existing foreign affiliates. The experiences of Singapore and Ireland (box VII.6), for example, suggest that close collaboration with existing investors can pay off, if supported by other policies to make the host-country environment more conducive to such investments.

The extent to which IPAs actively engage in the promotion of R&D-related FDI differs by region and country. In an UNCTAD survey conducted in February–April 2005, involving 84 national IPAs,[33] as many as 46 (or 55%) of these IPAs reported that they actively promote FDI in R&D (table VII.1).[34] A large number of IPAs in developed countries — including six of the new EU members — promote it (79%), as do 46% of the IPAs based in developing countries. By subregion, the highest percentage was noted for IPAs in Asia and Oceania. Conversely a minority of IPAs in Africa actively promote R&D-related FDI, and only 11% of the LAC IPAs that participated in the survey do so.

In terms of industry focus, computer and ICT services are the most commonly targeted industries by IPAs in both developed and developing countries that promote R&D-related FDI. In developed countries (excluding the new EU members), many IPAs also target such FDI in chemicals and chemical products (including pharmaceuticals) along with motor vehicles and other transport equipment; developing-country

Box VII.5. The IPA's role in the Czech NIS

IPAs frequently find themselves operating in significant policy vacuums, partly due to a lack of coherence between FDI and science and technology policies. Only recently have Government policies in the Czech Republic aimed at encouraging and fostering an innovation and technology culture, moved to centre stage.

Essentially, CzechInvest's expanded role in stimulating and securing R&D and innovative activities can be traced back to the year 2000, as a response to three main factors:

- Increased competitive pressure;
- A shift in the agencies strategy from labour-cost-sensitive manufacturing to business support services and technology centres; and
- Positive results from a location audit that benchmarked the Czech Republic against leading recipients of R&D-related FDI.

The results of the location audit also suggested a need for CzechInvest to help bridge the gaps between different policy fields. For example, the incentive regime was exclusively aimed at manufacturing, the supply of suitable property options was limited and the link between universities and enterprises was not sufficiently strong. CzechInvest had the expertise and strong support to initiate and oversee the administration of a new incentive regime aimed at enhancing factor conditions underpinning R&D and innovation activities.

The number of business support services and technology centre projects in the Czech Republic increased to 41 in 2004. This alone is insufficient to ensure the sustainable development of science and technology in the country. CzechInvest continues to fulfil a policy advocacy role, and designs and administers EU Structural Fund programmes aimed at enhancing innovation; it has also fostered a deep-rooted partnership with key constituents. It has joined with the Ministry of Industry and Trade to design and implement two programmes specifically aimed at supporting innovation.

Also involved are the office of the Deputy Prime Minister, Economic Affairs; the Department of Research, Development and Innovation; and the Council for Research and Development.[a]

The implementation of policies aimed at developing the skills and capacities to sustain the growth of R&D activities and innovative knowledge-based industries will take time. All the conditions needed to stimulate and sustain growth in knowledge-based industries cannot be provided by domestic means and resources alone. Consequently, CzechInvest will continue to target companies with mobile R&D and technologically advanced innovative projects while simultaneously fulfilling a policy advocacy role aimed at enhancing competitiveness. Such policy advocacy could manifest itself in the creation of a new technology agency modelled on best international practices operating as an integral unit of, or running in close association with, CzechInvest.

Source: CzechInvest.

[a] The Department of Research, Development and Innovation has established steering committees for each of three priority areas (life sciences, technical/engineering sciences and social sciences) while the Council for Research and Development facilitates decisions on the efficient use of Government funding for research, which was about 550 million euros for 2005.

IPAs pay relatively much attention to R&D by TNCs in agriculture. IPAs were also asked to specify what tools they use to promote FDI in R&D. Most agencies mentioned "general investment promotion" (such as missions, seminars and websites), followed by the setting up of science parks and the provision of tax incentives for R&D activities (table VII.2).[35] The use and effectiveness of performance requirements, incentives and science parks is discussed in more detail in subsequent sections of this chapter.

Table VII.1. Do IPAs actively target FDI in R&D?
(Number of responses)

Region	Yes	No
All economies	46	38
Developed countries (excl. new EU members)	9	3
New EU members	6	1
South-East Europe and CIS	5	4
Developing countries	26	30
Africa	9	13
Latin America and the Caribbean	2	16
Asia and Oceania	15	1

Source: UNCTAD survey of IPAs, February–April 2005.

Box VII.6. Enhancing the benefits from R&D-related FDI: the case of Ireland

In Ireland foreign affiliates account for about two-thirds of business expenditures on R&D; this is mainly in ICT (75%) and another 20% is in pharmaceuticals and medical devices. However, R&D expenditures per employee in foreign affiliates are still below levels prevailing in other European economies with a high-tech industrial structure such as Finland and Sweden. To boost innovation by both domestic and foreign companies, the development agencies — IDA Ireland, Enterprise Ireland and Forfás (the national policy and advisory board for enterprise, trade, science, technology and innovation) — in the 1990s jointly pushed for greater emphasis on science, technology and innovation.

The release in 1996 of the first-ever Irish Government White Paper on Science, Technology and Innovation emphasized the importance of these areas. As a result, under the National Development Plan 2000-2006, there was a five-fold increase in investment in these areas, from 0.5 billion in 1994 to 2.5 billion in 1999.[a] Moreover, in 1998 the Programme for Research in Third-Level Institutions was launched, which established 24 major research centres as well as major programmes in human genomics and computational physics. A Technology Foresight exercise in 1999 identified biotechnology and ICT as priority areas for R&D support by Science Foundation Ireland.[b] Finally, a 20% tax credit for incremental R&D was introduced in the Finance Act of 2004.

With a view partly to enhancing the interaction between enterprises and academia in Ireland, Science Foundation Ireland – in collaboration with industrial partners — has set up six Centres for Science, Engineering and Technology: three in the bio-medical field and three in ICT. The development agencies also conduct various activities to promote business-academia linkages, including the promotion of networks and clusters. In addition Enterprise Ireland, IDA Ireland and Science Foundation Ireland are considering the introduction of pilot schemes to fund academic researchers to spend periods working in industry and vice versa.

These policy efforts are expected to enhance the benefits from R&D activities undertaken by foreign companies in Ireland. The country has managed in recent years to attract several significant R&D projects by TNCs. During the period 2002-2004 more than 40 such projects were recorded (LOCOmonitor database). In several cases the foreign companies have collaborated with local academic institutes. Examples include:

- Bell Labs' R&D centre at Lucent Technologies' Dublin facility, linked with the establishment of a collaborative academic centre at one of the city's universities.
- Hewlett-Packard's technology development centre at its manufacturing facility outside Dublin, and the Digital Enterprise Research Institute in collaboration with University College Galway.
- Intel's innovation centre outside Dublin and the expansion of its R&D centre near Limerick. Intel has also partnered three Irish universities in the creation of an academic Centre for Research on Adaptive Nanostructures and Nanodevices.

Source: UNCTAD, based on Ireland, Department of Enterprise, Trade and Employment 2004 and Barry forthcoming.

[a] Despite this increase in State spending on research, R&D expenditures in higher education and the public sector remain below the EU average (Ireland, Department of Enterprise, Trade and Employment, 2004, p. 10).

[b] Science Foundation Ireland funds selected research programmes (153 by mid-2004, employing more than 750 researchers) and five joint partnerships between tertiary level research institutions and industry.

2. Performance requirements

Some countries have applied performance requirements to induce TNCs to undertake more R&D and other innovatory activities in their economies. In this context the most relevant instruments are R&D requirements, but technology transfer and joint-venture/equity-ownership requirements may also play a role.

Both developed and developing countries have applied specific *R&D requirements* to foreign investors. For example, some developed countries have imposed R&D requirements as a condition for entry to address the concern that most R&D activity of TNCs tends to remain in the home country (UNCTAD 2003c, chapter VI). In India, R&D requirements have been imposed on both foreign and local investors to encourage

Table VII.2. Policies and policy tools used by IPAs promoting FDI in R&D
(Number of times the tool has been mentioned; multiple answers possible)

Policies and policy tools	All economies	Developed countries (excl. new EU members)	New EU members	South-East Europe and CIS	Developing economies	Africa	LAC[a]	Asia and Oceania
General investment promotion	36	7	6	5	18	7	1	10
Setting up of science parks	26	5	5	2	14	4	-	10
Tax incentives for R&D	26	3	3	3	17	7	1	9
Promotion of linkages between foreign affiliates and universities	24	4	4	2	14	6	1	7
Strengthening of intellectual property rights	22	2	2	2	16	6	2	8
Grants for R&D activities	20	4	6	2	8	2	-	6
Reduced tariffs on imported R&D equipment	14	-	-	1	13	8	-	5
Special incentives to attract foreign researchers	9	3	-	2	4	2	-	2
R&D requirements as a condition for entry	7	-	1	2	4	-	1	3
Other policy tools	12	3	2	1	6	1	-	5

Source: UNCTAD survey of IPAs, February–April 2005.
[a] Latin America and the Caribbean.
Note: Based on responses from the 46 IPAs that stated that they target FDI in R&D.

them to set up in-house R&D facilities or to enter into long-term consultancy agreements with local R&D institutions. However, requirements have tended to be minimal and are seldom closely monitored (UNCTAD 2003c, chapter III).

In China, requirements to undertake R&D are imposed as a condition for entry in selected industries where the inflows of FDI may be considerable but where TNCs have not undertake R&D activities. A prominent example is the passenger car industry. In an effort to tackle the relatively slow enhancement of domestic innovation capability, the 2004 industrial policy required the establishment of an R&D centre with an investment of at least 500 million yuan (about $60 million) for any new automotive project to be approved.[36] Although the provision largely deters the entry of domestic players into that industry, it has contributed to changing the attitude of TNCs on R&D localization.[37]

The rationale for imposing a *technology-transfer requirement* may be to induce foreign affiliates to adopt technologies that are appropriate to the factor endowments of the specific host economy and to facilitate knowledge transfer. However, TNCs are unlikely to channel proprietary information and knowledge unless it is also in their interest. A review concluded that explicit requirements for transferring technology have not been used very often (UNCTAD 2003c).[38] In two studies of Japanese and United States FDI, no positive impact was found of related performance requirements on the extent to which technology was transferred to foreign affiliates (Urata and Kawai 2000, Blomström et al. 2000, pp. 216-217). The implementation of technology transfer requirements can be a challenge, mainly due to the difficulties involved in measuring the extent to which transfers occur and in determining what technology is desirable.

Joint-venture and equity-ownership requirements have also been used to promote diffusion of knowledge and technology from foreign affiliates to local counterparts, with mixed results. Some researchers have found that technology employed in foreign affiliates established in response to joint-venture requirements tends to be three to ten years behind the cutting edge for the industry concerned and that the amount of technical training provided to local managers and workers is often a fraction of that received in wholly-owned affiliates (Moran 2002).[39] Meanwhile, others argue that even if the content and quality of technology are superior in the case of wholly-owned ventures, the presence of a local partner may increase the opportunities for local learning and diffusion of whatever knowledge is created locally or transferred from abroad (Yun 2002).

There is always a risk that the use of performance requirements repels some FDI. In general, for countries in a stronger bargaining position vis-à-vis the foreign investors (e.g. owing to a large domestic market), this risk is lower. China and India have been able to attract considerable amounts of FDI in R&D while imposing various requirements as mandatory conditions for entry or as conditions for providing an incentive. The use of mandatory R&D or joint-venture requirements in smaller economies would increase the risk of losing FDI, unless the foreign investors are compensated (e.g. through various fiscal or financial incentives). Even for such "voluntary" R&D requirements, without other conditions in place – such as an adequate supply of local capabilities and technical skills — fiscal and financial incentives linked to R&D requirements are likely to have a limited impact. Conversely, if other factors are in place, the foreign investors may decide to locate R&D activities in the host country even without an extra inducement through incentives.

3. The use of R&D incentives is expanding

Most developed countries and a growing number of developing countries use some form of incentives to attract R&D activities. In many cases government support is offered to both domestic and foreign firms on equal terms. Evidence suggests that R&D incentives could have a *marginal* impact (i.e. they might tilt the balance in favour of a specific location) when countries with similar factor endowments are competing for an FDI project. In general, however, other locational factors are more important determinants. In considering the use of R&D incentives, governments should examine carefully what incentives are the most appropriate, taking into account budgetary and administrative implications.

The rationale for government support for R&D is a presumption that, if left to the market, private firms will underinvest in R&D due to the problems of appropriability and the high degree of uncertainty associated with R&D investment.[40] Incentives may aim to secure socially optimal levels of R&D.[41]

However, there are several pitfalls in providing R&D incentives. As is the case with other types of incentives, international competition among countries in offering incentives could result in the wasting of public funds as well as global economic distortions. Defining "R&D expenditures" is also problematic. A broad and simple definition is likely to result in an unnecessarily generous system, while a more targeted system involves more complex administration. Whatever the definition, firms may resort to "re-labelling" so that costs not related to R&D are counted as R&D expenditures in order to benefit from favourable tax treatment. Another problem is related to the evaluation of R&D support programmes. It is almost impossible to ascertain whether the benefits (spillover effects) justify the costs of subsidies or foregone tax revenues. Finally, there is a risk that a government might end up supporting R&D projects that firms would have undertaken even without its support.

Government support for R&D broadly takes the form of financial and fiscal incentives (box VII.7). UNCTAD's survey of IPAs (see above) indicates that more than half of the agencies that target FDI in R&D offer tax breaks for such activities and in 43% of the cases R&D grants were provided (table VII.2). While the picture is not uniform, the use of such R&D incentives is on the increase, especially in *developed countries*. EU countries are making the greatest efforts to promote R&D activities by way of incentives[42] and Austria, Denmark, Italy (for SMEs only), Portugal, Spain and the United Kingdom have some of the most generous R&D incentive systems (OECD 2003), while France, Ireland and the United Kingdom all made their tax treatments of R&D more favourable in 2004 (MacDougall 2004). Notable exceptions among the EU members are the Nordic countries. With regard to financial incentives, the European Commission in 2005 set out a seven-year plan to increase R&D spending in the EU by way of grants worth 70 billion.[43] The plan was a response to the slow progress towards EU members' pledge to increase R&D spending to 3% of GDP by 2010.[44] Outside Europe, the most generous fiscal incentive schemes are offered by Australia and Canada.[45] In the United States, tax credit for R&D is the most significant of the remaining domestic tax credits.[46]

Partly due to limited resources, *developing countries* are more likely to apply fiscal than financial incentive schemes. In the UNCTAD survey of IPAs, more than twice as many developing-country IPAs used tax incentives than those who used financial incentives (table VII.2). Many developing countries also charge lower tariffs on imported R&D equipment as a way of promoting technology transfer.

The two largest emerging-market destinations of FDI in R&D, China and India, have strengthened their systems of R&D support. In China, TNCs can set up R&D centres as independent entities (under the rules applying to Sino-foreign joint ventures), wholly foreign-owned enterprises or as independent departments or branches of existing companies. Equipment and parts imported by R&D centres meeting certain requirements are exempt from customs duties and import value-added tax, and the technologies they develop and use are exempt from business tax.[47] India offers *inter alia* a ten-year tax holiday for companies engaged exclusively in scientific R&D with commercial applications (EIU 2004n).

Most other Asian countries that have attracted significant FDI in R&D also provide extensive R&D support. In Malaysia, companies can offset 100% of capital expenditure incurred within ten years against 70% of their income.[48] Singapore allows a 100% deduction of R&D expenses (in certain cases 200%) and provides various grants and tax exemptions.[49] Thailand revamped its system of R&D incentives in 2004, after which firms can be entitled to a corporate income tax holiday for up to eight years (EIU 2004p).

In Latin America, the use of government support for R&D is less widespread. For example Argentina, Chile and Mexico[50] do not have significant fiscal measures to promote R&D. Brazil, on the other hand, allows locally owned IT firms[51] to deduct some R&D expense from their taxable income, and research financing is available for research projects in bioscience, physics, chemistry and environmental science (EIU 2004q). Colombia also offers investors in R&D centres certain fiscal tax exemptions (EIU 2004r). While there is little information on the use of incentives in Africa, South Africa allows accelerated depreciation of assets in certain targeted areas, including R&D investment. Both foreign and domestic firms are eligible for tax incentives. The Government also provides some direct financial support for R&D (EIU 2004s).

Despite the proliferation of financial incentives for R&D, few studies have assessed their effectiveness. An analysis of the Small Business Innovation Research Program in the United States found that firms awarded subsidies under this programme enjoyed greater sales and employment growth and increased their chances of receiving venture capital financing (Lerner 1999). Another study, conversely, concluded that the subsidies granted under this programme did not affect employment of R&D personnel. Furthermore, there is evidence that subsidies have crowded out firm-financed R&D spending (Wallstein 2000).[52]

There are more studies on the effectiveness of *fiscal incentives*. They typically measure how much additional R&D expenditures are generated by a 1% reduction in the costs of undertaking R&D. Various studies have noted that the long-term impact of R&D incentives may be more important than the short-term ones (e.g. van Pottelsberghe et al. 2003, Bloom et al. 2002). However, it should be noted that these studies did not address the problems of re-labelling and input price inflation.[53]

Box VII.7. Types of R&D incentives

Two main types of R&D incentives can be distinguished: financial and fiscal. *Financial incentives* refer to direct funding of R&D projects by the government through the granting of preferential loans or subsidies. *Fiscal incentives* are tax based and can be further divided into six types: accelerated depreciation, tax allowance, tax credit, tax holidays, income tax allowances and import tariff exemption.

- *Accelerated depreciation* refers to a practice whereby faster depreciation rates are applied for current and capital R&D expenditures.[a] In most countries, non-capital R&D expenditures are treated as current expense, thus allowing the whole amount to be deducted from the taxable income during that year.
- Firms that are given *tax allowances* can deduct R&D expenditures from taxable income at a rate higher than 100%, resulting in a further reduction of corporate income tax liability.
- *Tax credits* also reduce a firm's corporate income tax, but the deductible amount is calculated differently. In this case a certain percentage of eligible R&D expenditures can be deducted directly from corporate income tax.
- A *tax holiday* exempts firms investing in R&D from paying taxes, or lowers the rates for a given period of time.
- *Tax allowances for personal income tax* and *import tariff exemption* can be targeted at personnel and products linked to the R&D activities of the firms.

Source: UNCTAD.

[a] This is an advantage for firms since R&D investments would normally be treated as capital expenditures, in which case only the amount that corresponds to the depreciation of such assets could be deducted from taxable income each year.

Regarding the factors that most influence TNCs' decisions on where to locate their R&D, a recent survey found that incentives, while important, are not a major determinant (EIU 2004a). Infrastructure and a tradition of innovation have the greatest impact. Nevertheless, government support can tip the balance in favour of a certain location when other factors are equally attractive (Cantwell and Mudambi 2000, chapter V).

As incentives are only one of many factors that influence the location of R&D, countries that continue to compete by offering incentives to attract such FDI need to be aware of the risk that the costs involved may eventually outweigh the benefits. In designing an incentive policy, governments also need to decide whether a more targeted approach or a more universal approach is the most appropriate. A targeted approach is more complicated and is likely to involve higher administration costs. Complicated incentive schemes also tend to be less effective.[54] A more universal approach (primarily fiscal incentives) requires larger resources, some of which will inevitably be used to support R&D projects that do not require any support.

One way to enhance the potential benefits from incentives is to promote R&D collaboration among local firms and/or institutions. Such a measure may help build domestic R&D capabilities by providing local R&D entities more opportunities for learning and funding. In Brazil, for example, some R&D incentives are provided only on the condition that the R&D is done jointly with research institutes and schools of high academic standing (EIU 2004q). Among developed countries, in Denmark firms can receive extra tax deductions on research projects co-financed by enterprises and public research institutions; in the United Kingdom companies are able to claim credit for R&D work which they subcontract to certain institutions including universities, charities and scientific research organizations (United Kingdom, Inland Revenue 2002).

4. Using science parks as attractors

Science parks are used to create a more conducive environment for innovation and R&D in enterprises, often in close proximity to universities and other public technical institutes. In UNCTAD's survey of IPAs, the setting up of science parks was the second most commonly mentioned policy tool used by those that target FDI in R&D. While their precise goals differ, such parks offer various kinds of support and networking activities, help newly started ventures and enhance cooperation between existing companies in the park. Many of them provide the specialized infrastructure needed to undertake R&D work. As locations for R&D-related FDI, science parks may offer attractive features by facilitating clustering and networking, offering access to skilled people, providing the necessary infrastructure and administrative support and, last but not least, offering a pleasant living and working environment. According to the International Association of Science Parks there were about 600 science parks in 2004 worldwide, hosting some 65,000 companies.[55] Two-thirds of all parks are located in the United States and Europe, and East Asia accounts for the bulk of all science parks in developing economies (Andersson et al. 2004, p. 152).[56]

A well-known case in Asia is the Hsinchu Science Park set up in 1980 in Taiwan Province of China. While it was originally established with a view to serving local companies, non-Taiwanese companies have also been attracted. In 2004, 52 out of 384 companies in the park were non-Taiwanese.[57] In Singapore, the first science park was also established in 1980 and now hosts 300 local and foreign companies (Zhang 2004). The Zhongguancun Science Park (Beijing) is China's first and largest science park with more than 14,000 high-technology firms, including 1,600 foreign affiliates (see also box VI.2). The offshoring of software development to India has often benefited from the presence of dedicated technology parks for IT services (*WIR04*). As of 2003 there were 39 such parks, accounting for 80% of all India's software exports in 2002/03.

A few science and technology parks have been established in different parts of Africa, especially in North Africa. Algeria, Egypt, Morocco and Tunisia all have at least one such park in place.[58] Madagascar and Senegal similarly host technology parks;[59] and in UNCTAD's survey of IPAs Ghana, Kenya, Mali and Nigeria stated that they use science parks to attract FDI in R&D. In South Africa a new park — "The Innovation Hub" — will become the first African science park that is accredited internationally. Its main objective will be to attract a variety of enterprises active in, *inter* *alia*, ICT, electronics, life sciences and aerospace.[60]

There has been limited use of science and technology parks in Latin America (IADB 2001). The first attempt at promoting innovative clusters was Brazil's creation of 13 "technological innovation nuclei" in selected universities and research centres in 1982 (Quandt 1999). Mexico started to create business incubators in 1990 with the support of the National Council for Science and Technology and the Association of Incubators and Technological Parks.

There is little evidence concerning the effectiveness of science parks. There appears to be some consensus that they can contribute to commercializing university-based knowledge and technology and can act as an important node in innovative clusters and in the NIS more broadly. As such they can also be useful tools in attracting FDI and embedding foreign affiliates in an NIS. However, establishing a park does not guarantee success. One issue concerns the financing of the park and the role of government support. It has been argued that governments should ensure strong private sector interest in any project before extending financial support, and that government support should be reduced as the park develops (IADB 2001). Another issue concerns the assigning of IPRs, especially if a science park facilitates the commercialization of university-based knowledge. Thirdly, in developing countries it is important to find a balance between providing employment opportunities for university students and avoiding the risk of draining skills away from universities (Andersson et al. 2004, p. 154). Fourthly, as science parks can constitute a key tool for the regional development of innovative clusters, the role of sub-national and local governments is decisive.

D. Industry-specific policies to enhance the benefits of FDI in R&D

In addition to specific policies geared to attract R&D by TNCs, various "flanking policies" are important to enhance the benefits from such activities. In this context industry-specific policies deserve particular attention as they have played an important role in encouraging indigenous production and innovation capabilities in developing countries. Such capabilities are central to sustaining technological and economic development and to reaping the benefits from R&D by TNCs. Policy formulation needs to reflect the fact that the nature of different industries varies considerably.

Industry-specific policies need to be defined in light of a country's overall development strategy. Within such a strategy, an industry-based vision can form the basis for deciding what R&D by TNCs to target and how to benefit from it, highlighting the need for close interaction between industrial and FDI policies. For developing countries it is important to take account of their development level and comparative advantage so that policy objectives are realistically set. For many low-income countries it may be appropriate to give priority to the development of less technology-intensive industries and services rather than high-technology ones.

What policy tools should be used depends in part on the industries a country seeks to promote. Appropriate policy formulation and design therefore requires in-depth knowledge of an industry, its production and technological capabilities and the kind of R&D that is undertaken locally. In countries that lack the knowledge base necessary for new product development in an industry, the enhancement of manufacturing rather than R&D capacity is likely to be the first priority for industrial development. Before moving towards R&D-based activities, a country first has to develop basic production capabilities (chapter III). For developing countries that already have significant manufacturing capabilities in some technology-intensive industries, policymakers may first consider promoting experimental development (by foreign affiliates as well as by local enterprises) in these industries. For more advanced developing countries with strong manufacturing capabilities in some high-technology industries, going from development to (applied) research is the major challenge.[61] The ultimate test for most countries is to foster national innovative capabilities in technology-intensive industries.

As many policy measures target R&D in specific industries, the boundary between industrial policy and science and technology policy becomes blurred, requiring close coordination between the two. In some countries the policy focus is shifting from "industries" to "clusters", which reflects the growing emphasis on inter-organizational relationships and networks in R&D and production (Freeman and Barley 1989, Olk and Young 1997). By fostering knowledge-based cluster formation,[62] industrial policy can encourage joint R&D efforts and knowledge spillovers involving both domestic firms and foreign affiliates.[63]

To enhance benefits from R&D internationalization, industry-specific policies also need to support entrepreneurship and foster the emergence of technology start-up SMEs. There is growing recognition of the role of SMEs in an NIS.[64] Small-sized technology start-up firms are often responsible for important innovations. While the relatively high concentration of R&D in large firms is a natural consequence of their ability to manage fixed costs and risk, SMEs tend to be more flexible and can therefore drive technological change at a faster pace than large firms. Thus SMEs can be especially important in high-technology industries.

However, small firms face several difficulties that can prevent them from fully realizing their technological and commercial potential. By making resources accessible and affordable to them, active SME policies can contribute to the emergence of an innovative domestic enterprise sector in new areas.

In high-technology industries governments can foster technology enterprise development through business incubation systems for technology start-ups. Such systems can provide young start-ups with the necessary resources and services (e.g. access to financing, networking, technical assistance and business consulting), help reduce non-commercial risks, support entrepreneurship and, thereby, the commercialization of R&D by these firms.

As part of efforts to build domestic enterprise capabilities in an industry there can be a need to strengthen the environment for technology start-ups by upgrading existing financial intermediaries and by introducing such financial instruments as seed and venture capital funds. Venture capital has been perceived mainly as a private sector activity, and in most developing countries governments have played a limited role in this area. However, there can be a role for public venture capital funds to compensate for the lack of private sources of venture capital needed to encourage R&D investment (Andersson and Napier 2005).

When carefully designed, business incubator and venture capital programmes function as complementary approaches. While business incubators help prepare the ground for growing firms and may compensate for some of the market failures that hinder the growth of new firms, venture capital provides both financial capital and expertise. Despite the obvious benefits and synergies deriving from close collaboration between incubators and venture capitalists, in reality such collaboration is far from automatic. Active policies are often needed to catalyse it.

In many instances industry-specific policies and SME policies directed towards technology start-ups need to be implemented at the local rather than national level. This is particularly important in large countries where comparative advantages and resource endowments of various locations may differ considerably. In Shanghai, for example, policies at the central level were complemented by strong local government support to attract FDI in the semiconductor industry and to build up an internationally competitive industrial base (box VII.8).

E. The role of home countries

Developed countries can help secure benefits from the internationalization of R&D to developing countries in different ways, including through the promotion of R&D internationalization and measures aimed at strengthening the NISs of developing countries.

The limited information available on home-country policies related to R&D internationalization suggests, however, that relatively few countries have specific measures in this area. A recent review of home-country measures in developed countries concluded that few governments support firms financially that want to conduct R&D abroad (OECD and Belgian Science Society 2005). Some financial mechanisms encourage joint collaboration in R&D activities, such as the EU Framework Programmes. In a few countries indirect funding of R&D (e.g. tax credits) is also granted if R&D expenditure is incurred outside the country (e.g. purchase of R&D services from foreign research institutes). Most jurisdictions among developed

Box VII.8. The role of local governments in building domestic capabilities: the case of Shanghai

Following decisions taken by the Central Government in China in June 2000, the municipal Government of Shanghai took a series of steps to develop the local semiconductor industry.[a]

- For projects on integrated circuit (IC) manufacturing it granted exemptions and reductions of local taxes and fees, facilitated the import, export and international travel of company employees and provided a 1% interest deduction of commercial loans denominated in renminbi.
- For IC design, it provided preferential treatment to firms and set up specific funds for the establishment of a technical platform, including a semiconductor intellectual property bank.
- Various agencies of the municipal government worked together to accelerate the upgrading of the semiconductor industry. Specific funding programmes (e.g. the Product-Design-Chip Project) were introduced and existing ones (e.g. the Technology-oriented SME Innovation Fund) were leveraged to enhance local technological levels and innovative capabilities.
- In terms of manpower development, education and research centres in relevant areas at local universities were encouraged and specific policies were adopted to attract highly skilled human resources from within China and abroad. The municipal government also established a programme to attract Chinese returnees to form start-ups for conducting R&D in Shanghai.
- In 2003, a semiconductor intellectual property exchange centre was set up to serve as a platform for IPR protection and trading, and a specialized guarantee fund was launched to address the financing problem facing small IC design companies.
- To encourage linking together downstream and upstream firms in the value chain, the local government also introduced the Specialized Project to Encourage the Collaboration between Final Product Industry and IC Design Industry.

Source: UNCTAD.

[a] This took place right after the Central Government had introduced "Several Policies to Encourage the Development of the Industries of Software and Integrated Circuit" (File No. 18).

countries that grant R&D incentives do so irrespectively of whether the R&D supported is undertaken inside or outside the country. However, Belgium, France, Japan and Spain require (at least for some incentives) that the R&D is conducted in the respective country (IBFD 2004, pp. 222-230).

Some developed countries provide support to domestic public institutions to undertake R&D activities abroad, including in developing countries. For example the Australian Centre for International Agricultural Research promotes partnerships between Australian and developing-country institutions. It supported more than 50 R&D projects in Viet Nam between 1993 and 2003 (UNCTAD 2004, p. 10). The French Centre for International Cooperation on Agricultural Research for Development provides new and emerging technologies related to sustainable agricultural development and conservation of the environment in Africa, Asia and Oceania, Latin America and Europe. Its researchers, posted in 50 countries, work with national research organizations or provide technical support in development projects (ibid., p. 27).

A growing number of developing-country TNCs — mainly from Asia — also conduct R&D abroad to access technologies, skilled human resources, unique innovative networks and attractive innovation environments (chapter IV). Some Asian governments, such as those of China, India, Malaysia and Singapore, actively facilitate and encourage outward FDI,[65] but few specifically encourage FDI in R&D. The only known example in this regard is China. In the context of its "go global" strategy[66] the Government of China has promulgated a series of regulations and circulars in recent years to manage and encourage overseas investment by Chinese enterprises.[67] The country adopts a selective support strategy.

In October 2004 the National Development and Reform Commission (NDRC) and the Export-Import Bank of China (EIBC) jointly issued a circular encouraging overseas investment projects in four areas, including "overseas R&D centres that can utilize internationally advanced technologies, managerial skills and professionals" (see also chapter II). Preferential credit is granted for investments in these four areas and the NDRC and the EIBC have established a joint supportive mechanism to promote such outward FDI. The EIBC specifically arranges "special loans for overseas investments" within its export credit plan in order to support the identified investment projects. It accelerates the process of project screening, and the NDRC also facilitates contacts with other agencies to improve the risk-control mechanism for overseas investment. The encouragement of R&D abroad reflects the efforts of the Government to enhance China's innovative capability by leveraging foreign resources.

An indirect way for home countries to help developing countries derive greater benefits from R&D internationalization is to assist them in strengthening their NISs. However, bilateral aid organizations rarely focus on science and technology, and when they do the aid tends not to be effective:

> "A few bilateral development agencies have a strong focus on science and technology. But even where such programs exist, they lack strong links with domestic scientific institutions in donor countries…Aid programs need to reflect the view that the best way to address poverty is to stimulate economic growth. This will require a focus on science, technology, and innovation" (UN Millennium Project 2005, p. 165).

There is scope for more bilateral cooperation to foster policy formulation and stronger innovation systems in developing countries (UNCTAD 2005d). A key area in this regard is human resource development. The domestic educational systems in many poor countries, especially in Africa, are not sufficiently flexible or well-funded to achieve the needed increase in the number of tertiary students. The international community could play a more active role in this area, for example, by strengthening the local educational infrastructure and by making education opportunities to developing countries available in developed countries. Many developed countries already provide developing-country students with scholarships for higher education in their countries.[68] Some also provide developing countries' academic, research and professional institutions with research and equipment support (UNCTAD 2004, p. 11). It has been proposed that developed countries establish a second "Colombo Plan" for sub-Saharan Africa under which students from African countries could study abroad.[69] To address the risk of brain drain, special provisions would, however, have to be made to ensure that students return to their home countries upon completion of their studies (UN Millennium Project 2005).

Efforts by home countries to improve the institutional framework for innovation in developing countries could help establish technical standards and certification systems through access to and provision of testing equipment for standard setting and quality assessment (UNCTAD 2004, p. 15). Similar steps could be taken in the area of IPRs and through R&D collaboration between institutions in developed and developing countries. In the health sector some developed-country governments have funded R&D public and private institutions in developing countries to develop drugs and vaccines. Such support has mainly involved financing research, conducting trials and providing mechanisms for delivery of services to end-users (UNCTAD 2004, p. 9). Moreover, the EU has contributed to the NISs of developing countries by encouraging an exchange of scientists and closer interaction between universities in developing countries and EU member countries (UNCTAD 2005d, para 27).

F. Concluding remarks

Today, no country can rely entirely on knowledge created within its borders. The challenge facing countries is therefore to ensure that they connect in the most effective way with global R&D networks of TNCs and the innovation systems of other countries. Inward as well as outward R&D-related FDI can here play a role. In order to derive benefits from the current trend of R&D internationalization, this chapter has underlined the need for active government policies in a number of areas, and that such intervention is done in a coherent way. For the many developing countries that are currently not taking part in the process of R&D internationalization, important lessons could be drawn from the experience of other countries.

In all the developing economies that have been successful in improving their innovation capabilities and in attracting R&D by foreign companies, the government has played a key role.

In particular, while their strategies differ they have all sought to strengthen their innovation systems by enhancing their "created assets", notably their human resources, and their institutional frameworks affecting the incentives and conditions for firms to innovate. But in order to be effective, such policies demand political commitment and a clear, long-term vision. A country that simply opens up to trade and investment and passively waits for new knowledge and technology to flow in from abroad is likely to be at a competitive disadvantage vis-à-vis those that actively adapt and strengthen their policies and institutions.

The ability of a country to benefit from R&D internationalization depends first and foremost on the strength of its NIS. The stronger the NIS, the greater is the likelihood not only of attracting R&D by TNCs but also of spillover benefits arising from inward as well as outward FDI in R&D. Policies on human resource development, promotion of linkages between R&D activities in the public and enterprise sectors, strategic use of IPR systems and competition policies are key in this respect. Efforts in these areas need to be closely coordinated with investment policies. Indeed, a coherent approach is required to ensure that government interventions are effective in securing benefits from R&D internationalization. In essence, policies in the areas of innovation, education, competition, FDI as well as those targeting the needs of specific industries and SMEs need to be seen as part of a vision aimed at enhancing competitiveness and development.

Active and coherent policies are among the most striking features of those developing countries that are now emerging as nodes in the R&D networks of TNCs. The success of some Asian economies is no coincidence. In most of them the starting point has been a long-term vision of how to move the economy towards higher value-added and knowledge-based activities. In many instances, targeted government policies aimed at strengthening the NIS and facilitating knowledge inflows. Such policies have included:

- Active promotion of imports of technology, know-how, people and capital from abroad; some have relied on inward FDI while others have linked up with the TNCs through contractual arrangements.
- Strategic investment in human resources to support technological upgrading in the private sector - typically with a strong focus on science and engineering.
- Continuous improvement of educational systems.
- Promoting immigration or the return of skilled workers in the diaspora.
- Development of infrastructure (such as science parks, public R&D labs, incubators) that helps promoting innovation in the NIS by both foreign and local firms.
- Use of performance requirements and/or incentives as part of an overall strategy to attract FDI in targeted activities.
- Strategic implementation of IPR protection.

Effective implementation of policies in these areas requires collaboration between relevant government bodies and coordination at the highest level. There is also a need to delineate the responsibilities of individual ministries and agencies at both the national and sub-national levels. Because R&D activities have a strong tendency towards geographic clustering, government agencies at the local level can play an important role in attracting FDI in R&D to specific localities by establishing science parks, providing specific incentives and facilitating the mobility and availability of technically qualified people. Moreover, in designing and implementing their policies, governments need to understand what determines the location of R&D, how R&D by TNCs interacts with other actors within the NIS of a country and how to connect effectively with other systems of innovation.

For many developing countries at the lower ranks of the *UNCTAD Innovation Capability Index*, any expectation of a major influx of R&D by TNCs would be unrealistic in the short-term. That is not a reason for inaction, however. Rather, countries should consider how to begin a process through which economic and technological upgrading can be fostered. As argued by one expert (Lewanika 2005, p. 12):

> “An important starting point for developing countries is to increase the percentage of GNP devoted to education, science teaching as well as research and development. The notion that investing in science and technology is a time-consuming, wasteful and costly activity will condemn developing countries to perpetual economic illness. Initiatives to assist Third World countries to develop

must include science, technology and innovation as one of its main themes."

Successful efforts at the interface of investment, technology and industrial policies are essential in order for more countries to benefit from the current trend towards greater internationalization of R&D. Recent developments have shown that developing countries can play a role even in highly sophisticated R&D by TNCs. Currently the phenomenon is confined to relatively few developing and transition economies, but R&D internationalization is expected to deepen and potentially involve more countries. This process is still in its infancy. The fostering of innovative capabilities is a long-term task for governments. For latecomer countries, ensuring that a process aimed at strengthening the NIS gains momentum can be seen as a first necessary step.

For developed home countries, current trends accentuate the need for relying more on the creation, diffusion and exploitation of scientific and technological knowledge as a means of promoting growth and productivity. Rather than regarding R&D internationalization as a threat, these countries may seek to seize the opportunities it offers. Reverting to protectionism most likely would harm the ability of their firms to compete. Instead, it will be important to explore new ways of collaborating with the new R&D locations, such as through joint research programmes and outsourcing as well as through inward and outward R&D-related FDI. To facilitate such collaboration, and to help more countries build the necessary capabilities to participate in the process, developed countries may decide to offer additional support aimed at strengthening various aspects of the innovation systems of countries which currently have weak innovative capabilities. Such contributions could effectively help in the overall efforts to narrow the technology and innovative capability gap that may otherwise continue to widen.

Notes

1 In many parts of Africa, for example, academic education has often produced skills demanded in public administration rather than in industry. African institutions of higher education enrol 60% of students in the arts and humanities and only 40% in science and engineering (Oyelaran-Oyeyinka 2004a, p. 20).

2 In Malaysia, for example, such needs were identified for electrical and electronics engineering, information technology, communications technology and circuit design personnel who are able to combine hardware, software and application knowledge (Ernst 2004).

3 UNCTAD interviews.

4 See also *WIR01*, chapter V, for examples on how countries have involved foreign affiliates in training and technological upgrading of suppliers.

5 Among those working in science and engineering occupations in 2000, 17% with bachelors' degrees, 29% with masters' degrees and 38% with doctorates were foreign-born (Ernst 2005a). In 2001, 133,000 foreign citizens were enrolled at the graduate level in science and engineering in the United States. This corresponded to more than 30% of the total number of science and engineering graduates that year, an increase from 20% in 1983 (United States, NSF 2004, appendix table 2-12).

6 See ISA (2004) and "The brain drain: old myths, new realities", *OECD Observer*, May 2002.

7 Tertiary technical institutions in Singapore also attract a large number of foreign students. According to figures from the Singaporean Agency for Science, Technology and Research (A*STAR), 79% of full-time postgraduate research students in science and engineering were foreigners in 2003.

8 "Singapore aims to be a biotechnology hub", *Financial Times*, 10 June 2005.

9 In 2003 only 2.7% of all professors were non-Korean, foreign students at universities accounted for only 0.2% of all enrolled students and there were few foreign workers in the private and public sectors (Kwon 2003).

10 Some estimates suggest that around 300,000 professionals from the African continent live and work in Europe and North America (see "The brain drain: old myths, new realities", *OECD Observer*, May 2002). Many countries in Latin America have also been exporting human resources (ECLAC 2002, chapter 8). At the beginning of the 1990s, some 300,000 Latin American and Caribbean professionals and technicians were living outside their home country; over two-thirds of that total were concentrated in the United States (Villa and Martínez 2001).

11 "In a 'brain gain', India's Westernized émigrés return home", *International Herald Tribune*, 26 July 2004.

12 This programme coincided with a World Bank Industrial Technology Development project, one component of which was to upgrade the technology institutions and strengthen their linkages with industry. The project helped shape the direction of reform and provided technical assistance to help reorient the laboratories and train their managers and staff.

13 In 1996, outside earnings contributed to 16.4% of total expenditures, and some laboratories, such as the National Chemical Laboratory in Pune, were even more successful, earning over 50% from industry, the bulk of which came from foreign contracts.

14 Communication from CSIR, May 2005.

15 The TRIPS Agreement also covers industrial designs and layout designs of integrated circuits.

16 Not all pieces of knowledge can be patented. For example, information obtained in the process of an R&D project before its completion may be valuable, but it does not constitute an invention as such and therefore cannot be patented. Even when an invention can potentially be patented firms may prefer not to

disclose the details of their intellectual property through patenting. In these circumstances such information can be kept as a trade secret.

17 For more information, see UNCTAD (2004), and relevant papers at www.unctad.org/trade_env/TK2.htm.

18 While the legal process was taking place the patent was sold on to other firms although the Government of the United States remained the co-proprietor of the patent.

19 *ICTSD Bridges Weekly News Trade Digest*, 23 May 2005 (www.ictsd.org).

20 In countries where the IPR regime allows patenting in new areas such as software, business models and financial formulae, the required range of expertise is even wider.

21 See also Cimoli and Primi forthcoming and ECLAC 2004c.

22 According to the 1995 United States antitrust guideline there is a clear division of powers between IPR policy and competition policy in this area.

23 Schumpeter's economic analysis is a commonly used starting point. It argues that firms must make high levels of profits and enjoy some monopoly power in order to be able to invest in innovation.

24 Several attempts have been made to provide a theoretical explanation for this positive impact (e.g., Aghion and Howitt 1998, and Sutton 1998).

25 In the short run, competition is necessary to enhance the allocative efficiency of an economy and maximize consumer welfare. Beyond this *static* function, competition is a key driving force behind technological progress and long-term economic growth, thus influencing *dynamic* economic efficiency.

26 Innovations are strongly influenced by horizontal rivalry between competitors, but vertical relations are also important (Edquist 1997).

27 In the United States, "Guidelines for the Licensing of Intellectual Property" were issued in 1995 by the Department of Justice and the Foreign Trade Commission; the European Commission published its Regulation No 240/96 concerning Technology Transfer Agreements in 1996; and in Japan, "Guidelines for Patent and Know-How Licensing Agreements" were issued in July 1999.

28 In 2000, the "Antitrust Guidelines for Collaboration Among Competitors" were published in the United States, and the European Commission issued regulations regarding specialization agreements and R&D agreements. In 2001 the European Commission further introduced "Guidelines on the Applicability of Article 81 of the EC Treaty to Horizontal Co-operation Agreements".

29 For a discussion of cross-border M&As and their effects on competition, including limitations in this respect, see *WIR2000,* and Singh 2003.

30 Strategic behaviour aims to deter potential entrants rather than to destroy actual competitors. Vertical restrictions occur when a firm at one stage of the line of value-added activity imposes restraints on the terms of trading by firms at another stage. Vertical restraints include resale price maintenance, selective distribution systems, tying arrangements (tie-in sales), exclusive dealing and refusal to sell.

31 In Mauritius, for example, the Board of Investment is actively participating in the work of the National Productivity and Competitiveness Council to boost the country's innovation performance.

32 Republic of Korea, Ministry of Science and Technology 2003b; KICOS 2004.

33 The response rate was 55%.

34 This number is higher than that reported in the 2004 UNCTAD survey on FDI in services, in which only one-third of the IPAs responded that they promoted FDI in R&D activities (*WIR04)*. This may imply that an increasing number of IPAs are quickly responding to new opportunities created by the internationalization of R&D networks.

35 Frequent use of general promotion was also reported by IPAs that do *not* actively target R&D-related FDI.

36 This applies to both foreign and local companies.

37 For example, as part of the joint venture agreement between Nissan Motor and Dongfeng Motor Corporation, the building of an R&D centre began in December 2004. Meanwhile DaimlerChrysler, Honda Motor and Hyundai Motor, together with their respective local joint-venture partners, have announced plans to establish R&D centres in China. In addition Shanghai GM and Shanghai Volkswagen have both decided to expand their existing R&D centres. An estimated four billion yuan (about $0.5 billion) will be invested in R&D in the industry. See "Can four billion Yuan in R&D heal the pain of China's automotive technology?" *Jiefang Daily*, 26 January 2005. [In Chinese].

38 In South Africa for example, the Foreign Investment Grant, which was established in 2000, intended among other things to induce investors to bring in new machinery and equipment. As of 2003, the system had not been able to induce the level of technology transfer that the Government had hoped for (UNCTAD 2003c, pp. 196-197).

39 Similar findings were reported by Ernst 1999.

40 It is argued that Governments are better placed to take on risk than firms or financial institutions for two reasons. First, they may be able to spread risks over a larger number of projects. Secondly, they may assess the risks differently; even a commercially unsuccessful R&D project could be worth pursuing if it generates enough knowledge from which the society can benefit.

41 Although the estimates of the social return from R&D investment vary, empirical studies indicate that there are important spillover effects (Jones and Willams 1998).

42 For a recent comprehensive report on the tax treatment of the 25 EU member countries as well as the United States and Japan, see IBFD 2004. For more information on various schemes in use in developed countries, see Gregory and Botha, 2003. For country-specific information on R&D support programmes, see also EIU (2004b) for Australia, EIU (2001) for Austria, EIU (2004c) for Belgium, EIU (2004d) for Canada, EIU (2004e) for France, EIU (2004f) for Germany, EIU (2004g) for Greece, EIU (2004h) for Italy, EIU (2004i) for Japan, EIU (2004j) for Spain, EIU (2004k) for Switzerland, EIU (2004l) for the United Kingdom and EIU (2004m) for the United States.

43 "Brussels hopes research money will aid innovation", *Financial Times*, 3 April 2005.

44 A high-level group chaired by the former Prime Minister of the Netherlands, Wim Kok, had already

proposed that incentives be used to strengthen the science base and make the EU more competitive (European Commission 2004, p. 21).

45 See EIU (2004b) for Australia and www.irap-pari.nrc-cnrc.gc.ca for Canada.

46 Network World Fusion, www.nwfusion.com.

47 Circular of the Ministry of Foreign Trade and Economic Cooperation concerning the establishment of foreign-invested research and development centres, file No. 218, 18 April 2000

48 The rules differ somewhat between firms performing R&D on a contractual basis and those undertaking R&D in-house R&D (EIU 2004o).

49 Singaporean Economic Development Board, www.sedb.com.

50 In 2003 Mexico revoked its R&D credit, which was aimed at encouraging United States TNCs to shift more R&D activities to their Mexican affiliates, as the complexity of the system rendered it ineffective (EIU 2004t).

51 A company is regarded as "locally owned" if 51% of its voting shares are owned by Brazilian institutions or individuals.

52 In Israel an extra dollar of R&D subsides granted to the manufacturing sector was found to increase the long-run company-financed R&D expenditures by 41 cents on average, which was lower than expected given the dollar-for-dollar matching requirements upon which many subsidized projects are based (Lach 2000).

53 The problem of input price inflation refers to the difficulty of distinguishing the volume effect from the price effect. If incentives do stimulate extra R&D, they will result in an increased demand for input into R&D. If the supply of R&D inputs such as highly skilled professionals is limited, increased demand will result in raising the price of R&D inputs. Thus an increase in R&D expenditures as a result of public support may partly be accounted for by the inflated price of these inputs.

54 In Thailand, for example, few firms took advantage of an R&D tax break because of complicated regulations and the cost of the investment involved in the R&D schemes (EIU 2004p). The Government of Mexico in 2003 decided to revoke a 30% R&D tax credit that had provided incentives for United States companies to shift more R&D activities to their foreign affiliates in Mexico. The original measure had been ineffective due to too many exceptions and clauses (EIU 2004t).

55 See Sanz 2004. Other estimates suggest that there were over 1,000 science parks worldwide in 1990 (Andersson et al. 2004, p. 152).

56 In the Russian Federation, the State Duma approved the first draft legislation in June 2005 to set up research zones of up to 2 square kilometres and offered tax incentives. See "Duma bill aims for tech parks", *The Moscow Times*, 10 June 2005.

57 Communication from Hsinchu Science-Based Industrial Park, April 2005.

58 See, for example, UNIDO, *Technology Parks: Tunisia*, at: www.unido.org.

59 See e.g., United Nations Educational Scientific and Cultural Organization (UNESCO), www.unesco.org.

60 See e.g., www.theinnovationhub.com.

61 In Singapore for instance, the transition from manufacturing-related R&D to applied and even basic research began to take place as a consequence of proactive government policies targeted at TNCs involved in such manufactures as hard disk drives and telecom equipment in the 1990s (Amsden and Tschang 2003), and the biotechnology industry in recent years. In economies such as the Republic of Korea and Taiwan Province of China, the upgrading from manufacturing to development and then to research was mainly through domestic efforts rather than foreign TNCs.

62 See for instance, Porter 1997 and Dunning 1997.

63 See Roelandt and Den Hertog (1999) for cluster-based policy measures in various countries. In Thailand, for example, the Board of Investment (BOI) in 2004 initiated new investment packages for specific industrial clusters concerned with the manufacture of hard disk drives and semiconductors. Eligible firms in these clusters are not only final producers but also suppliers.

64 The relationship between firm size and innovative activity has been found to be ambiguous (e.g. Vossen 1996).

65 For instance the "Regionalisation Finance Scheme" in Singapore is a fixed-cost financing programme designed to assist Singapore-based enterprises set up operations abroad. It is part of the Government's effort to assist Singapore-based enterprises to internationalize their operations, sell in the global market place and leverage global resources in order to grow.

66 The "go global" strategy of the Government of China was formulated in the mid-1990s and formally announced in the *Suggestion from the Central Commission of the CCP on the Tenth Five-Year Plan on National Economy and Social Development* passed in October 2000 (www.people.com.cn).

67 These regulations include the 2004 *Interim Administrative Measures on the Approval of Overseas Investment Projects* (NDRC), the 2004 *Provisions on Issues Concerning the Approval of Overseas Investment and Establishment of Enterprises* (MOC), the 2004 *Circular on the Supportive Credit Policy on Key Overseas Investment Projects Encouraged by the State* (NDRC and EIBC) and various other regulations and circulars on foreign currency management, statistics, performance assessment and State-owned assets management (People's Republic of China, MOFCOM, www.fec.mofcom.gov.cn).

68 An example of mutually beneficial cooperation exists between France and universities in China. This cooperation has resulted in the training of highly qualified researchers who could find employment both in local institutes and firms, and in foreign affiliates of French TNCs (UNCTAD 2005d).

69 Under the Colombo Plan for Cooperative Economic Development in Asia and Oceania, donor countries have offered scholarships and fellowships to developing countries in the region since 1951. The Plan supported the development of scientific and technological expertise in a number of countries (UN Millennium Project 2005, p. 92).