Background paper for the United Nations Development Programme's

Human Development Report 2001: Harnessing Technology for Human Development

National strategies for technology adoption in the industrial sector: Lessons of recent experience in the developing regions

Sanjaya Lall

Professor of Development Economics, University of Oxford

1. Introduction

The concept paper for *HDR 2001* starts thus: "New technologies – especially biotechnology and information/communication technology – are the driving forces of competition between nations and people in the global knowledge economy of the 21st century. Access to and a share in the financial returns from technology will be an important determinant of whether an individual or a country is a winner or a loser in the global economy." It goes on to say "Acquisition of industrial technology has been an underlying factor in diversification, export growth and economic growth of Asian countries – what are the options for poor countries to adopt technological innovations to improve productivity and incomes in the context of a global competitive economy?"

This paper analyses the *uneven spread of new technologies in the developing world*, in terms of the success of different countries in using their potential to build viable and dynamic industrial sectors. It describes the structural factors that affect industrial success in terms of competing in a world of rapid technical change, shrinking economic distance and rapid policy liberalization. It illustrates the growing divergence between the 'winners' and 'losers' and explains why the process may be cumulative and self-reinforcing unless concerted policy remedies are undertaken at the national and international levels.

2. The setting

Let us start with the international setting within which developing countries have to develop and use their technological base. Broadly speaking, of course, the pace and impact of current technical change are so obvious and discussed at length in so many different places that there is little need to analyse it here.

However, it is useful to note some features that affect directly industrial growth and policies and that are less well known in terms of their implications for development strategy and industrial growth.

Freeman and Perez (1988) describe the current phase as a technological 'paradigm' shift.[1] How much of a real paradigm shift it is disputed by some, but what is beyond doubt is that technologies are changing at unprecedented rates, driven by a 'key' technology (microelectronics). The relative costs of this technology are dropping dramatically. Combined with the constant creation of new uses for its products (computing, information and communications broadly defined), the new key technology is being applied to practically all aspects of human activity. Other 'key' technologies also affect large areas of economic life – biotechnology and new materials are prime examples – often in close interaction with the leading technology. The overall effect is to amplify shocks to the economic and industrial system. Productivity is rising not just in the key technology drivers but also in all industries using their innovations. In all these senses, there does seem to be a paradigm shift.

The sheer speed and magnitude of technical change make the *ability to innovate and use new technologies* critical to industrial success.[2] Old technologies do not fade away but often become redundant at all factor prices. This means that no country, however poor, can insulate its productive sector from new

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[1] Freeman and Perez (1988) define a new technological 'paradigm' or revolution as follows: "A change of this kind carries with it many clusters of radical and incremental innovations, and may eventually embody a number of new technology systems. A vital characteristic … is that it has *pervasive* effects throughout the economy, i.e. it not only leads to the emergence of a new range of products, services, systems and industries in its own right; it also affects directly or indirectly almost every other branch of the economy." (p. 47)

According to their analysis, a new technological paradigm has the following features:

a. a new 'best practice' form of organisation in the firm and at the plant level;
b. a new skill profile in the labour force affecting both quality and quantity of labour;
c. a new product mix favouring products making intensive use of the new low-cost key factor (in this paradigm micro-electronics);
d. new trends in innovation to substitute the new key factor for other, higher cost, factors;
e. a new pattern in the location of investment nationally and internationally with shifting costs and patterns of comparative advantage;
f. a particular wave of infrastructural investment to provide appropriate externalities throughout the system and facilitate the use of new products and processes;
g. a tendency for new innovative small firms to enter rapidly expanding branches and in some cases to initiate completely new sectors of production;
h. a tendency for large firms to concentrate in branches where the key factor is produced and intensively used;
i. distinctively new branches of the economy act as engines of growth in each successive Kondratiev upswing;
j. new patterns of consumption of goods and services and new types of distribution. (p. 59)

They go on to note, "The uneven and varied response of governments, firms and industries to the threats and opportunities posed by information technology tends to accentuate the uneven process of development. Typically in the past, major changes in the techno-economic paradigm have been associated with shifts in the international division of labour and international technological leadership. Newcomers are sometimes more able to make the necessary social and institutional innovations than the more arthritic social structures of established leaders… On the other hand, countries lacking the necessary minimal educational, managerial, R&D and design capability may be even more seriously disadvantaged in international competition." (p. 64)

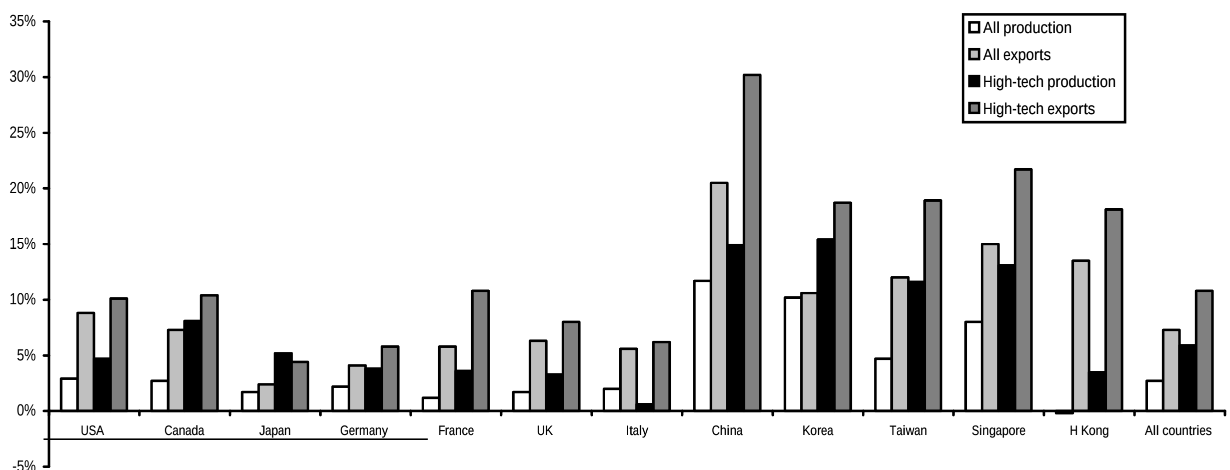
[2] The US Government's NSF (National Science Foundation) puts it as follows in its latest survey. "Most countries in the world acknowledge a symbiotic relationship between national investments in S&T and competitiveness in the marketplace. S&T supports business competitiveness in international trade, and commercial success in the global marketplace provides the resources needed to support new S&T. Consequently, the health of the nation's economy becomes a performance measure for the national investment in R&D and S&E." (NSF, 2000, p. 7-4)

technologies, regardless of wage or skill levels: liberalization and falling costs of shipping goods, people and information across long distances force all countries into the same arena. Note, however, my emphasis on the *use of technologies* rather than just innovation. Being an efficient and competitive producer does not require generating frontier technologies (though at a high level this is vital). It does entail using technologies effectively as they appear and change: we can call this 'technological capability' in a broader sense. Innovativeness as such matters for countries that have already mastered complex existing technologies – the fully developed and advanced newly industrialising countries – but for the bulk of the developing world it is the ability to efficiently absorb, use and adapt technologies that matters. In advanced countries also, the ability to diffuse technologies rapidly and effectively is vital to success, and there is much to learn from them.[3]

We should note two important features of technical change. First, all activities experience rapid technical involving rising information and skill intensity, but *dynamism differs greatly by activity according to its technological intensity*. Second, dynamism is also *highly concentrated* by country and region in the developing world, with a few 'winners' and many 'losers'.

We consider the first feature here and the second in section 4 below. Technology-intensive activities, defined as those with high research and development spending or high propensity to employ research scientists and engineers, have been growing much faster than others in recent years. Data from NSF (2000) show this for production and exports by all manufacturing and the subgroup of high technology industries during 1985-97 (Figure 1). The sample includes the major OECD countries as well as the leading Asian

Figure 1: Total and high technology manufacturing: annual growth rates 1985-97



[3] On the significance of technology diffusion in the advanced countries, this extract from an OECD study is interesting. "Technology plays a major role in shaping industrial performance: it affects productivity growth, creates and destroys jobs, changes skill requirements in the economy, and shapes the capacity of firms and industries to perform in international markets. Its potential economic gains are realised, however, as much from the widespread diffusion of new products and processes as from their initial development" (OECD, 1996.b, p. 9).

NIEs. More important, it includes all the major 68 economies in the world, accounting for 97 percent of global industrial activity. The general trend is clear. *High technology production is growing over twice as fast as total production for all countries* (the sole exception being Italy). Exports are growing faster than output, but *high-tech manufactured exports are growing much faster than total manufactured exports* (with no exceptions).

A recent paper by Lall (2000.a) provides a more detailed breakdown of manufactured exports by technological categories. The classification is shown in Table 1, and will be used later in analysing the growing divergence within the developing world. Primary products are separated from manufactures, with the latter divided into four main technological groups and nine subgroups. In broad terms, the first two groups (resource-based and low technology) can be regarded as technologically 'simple' and the latter two as 'complex'. While there are (inevitable) problems in classifying products by technology groups, and the three-digit SITC product level puts together some diverse technologies under the same heading, the results are interesting and plausible.

Table 1: Technological Classification of Exports

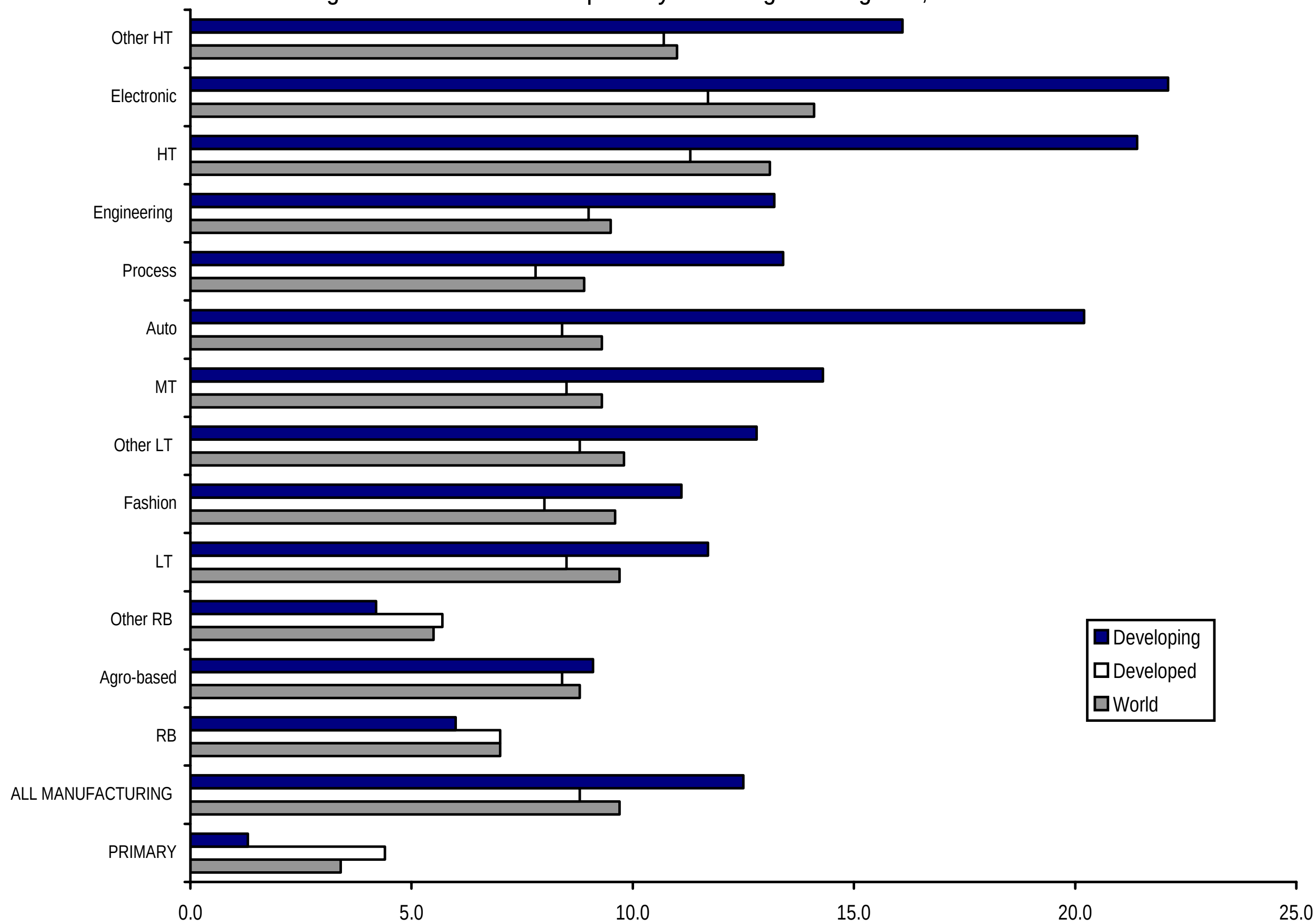
Classification	Examples
Primary products	Fresh fruit, meat, rice, cocoa, tea, coffee, wood, coal, crude petroleum, gas
Manufactured products	
<u>Resource based manufactures</u>	
Agro/forest based products	Prepared meats/fruits, beverages, wood products, vegetable oils
Other resource based products	Ore concentrates, petroleum/rubber products, cement, cut gems, glass
<u>Low technology manufactures</u>	
'Fashion cluster'	Textile fabrics, clothing, headgear, footwear, leather manufactures, travel goods
Other low technology	Pottery, simple metal parts/structures, furniture, jewellery, toys, plastic products
<u>Medium technology manufactures</u>	
Automotive products	Passenger vehicles and parts, commercial vehicles, motorcycles and parts
Medium technology process industries	Synthetic fibres, chemicals and paints, fertilisers, plastics, iron, pipes/tubes
Medium technology engineering industries	Engines, motors, industrial machinery, pumps, switchgear, ships, watches
<u>High technology manufactures</u>	
Electronics and electrical products	Office/data processing/telecommunications equip, TVs, transistors, turbines, power generating equipment
Other high technology	Pharmaceuticals, aerospace, optical/measuring instruments, cameras
Other transactions	Electricity, cinema film, printed matter, 'special' transactions, gold, art, coins, pets

Source: Lall (2000.a)

Figure 2 shows the growth rates of exports for 1985-98 by the main groups and subgroups for the world as a whole as well as for developed and developing countries separately. The main points that stand out here are:

◊ For the period as a whole, manufactured products were the engine of global export expansion, growing nearly three times faster than primary products. Within the main groups of manufactures, RB products grew the slowest and HT the fastest for all groups of countries. Products with 'natural' advantages (i.e. primary and RB manufactures together) were not dynamic; their combined share declined from 43% to 26% over the 13 years. HT products were the most dynamic, while LT and MT products grew at almost the same pace. In terms of value, MT products remain the largest category in manufactured exports, with about one-third of the total, but at current rates of growth HT products (now at over one-fifth of

Figure 2: Growth rates of exports by technological categories, 1985-98



the total) will soon overtake them. The 'complex' categories (MT and HT) comprise 54% of total world and 64% of manufactured exports in 1998.

◊ At the more detailed classification, the two HT groups took the lead for the world, with electronics dominating. Most LT and MT subcategories clustered around 9-10% growth rates. 'Other' RB products performed distinctly worse.

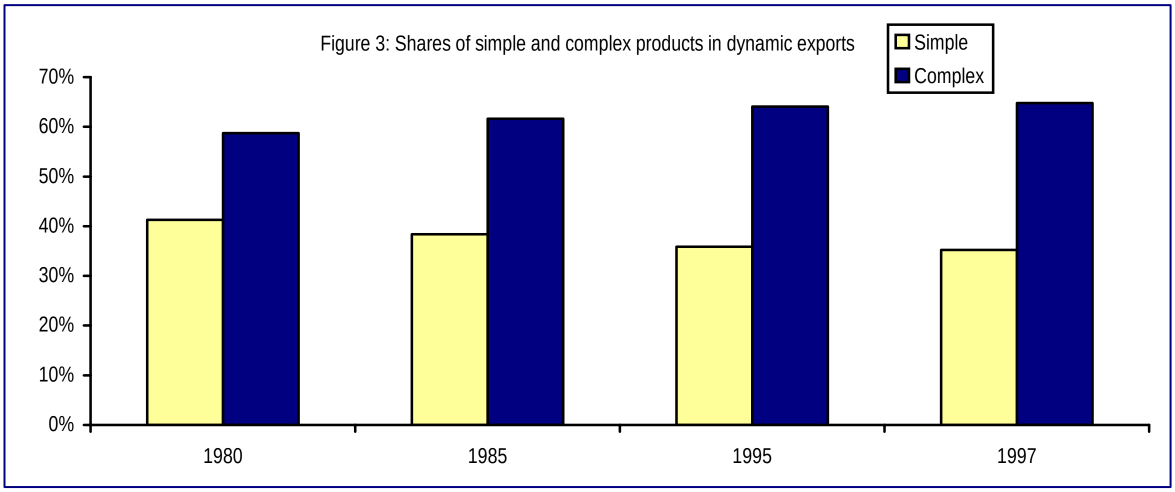
◊ Developing countries grew slower than developed countries in primary exports and RB manufactures. However, they grew faster in manufacturing as a whole and in most technological subcategories apart from 'other' RB. What is more interesting is that their growth lead over developed countries *rose with technological intensity*.

This picture is intriguing. While high-tech products are the most dynamic, growth rates do not rise uniformly over the technological spectrum. LT products match the performance of MT products. Clearly technology is not the only 'driver' of trade dynamism: the other is the *relocation* of export production (or rather, of labour-intensive processes) from high to low wage countries. The process has gathered momentum because of falling transport costs, trade liberalization and the launching of export-processing zones (with low-cost and non-unionised labour and tax incentives) by some developing countries. To some extent, however, this is a once-for-all adjustment because the overall market for many labour-intensive products like textiles and footwear are not growing rapidly. Sustained and long-term export dynamism is likely to depend on demand growth, the introduction of new products and substitution of old products – all strongly related to innovation. Thus, technology intensity is likely to remain the dominant force behind rapid export growth.

The relocation impetus for LT exports has been able to overcome relatively slow demand growth and technical progress (though some design-based segments have enjoyed faster growth). Primary and RB products have lost ground because low innovation interacts with slow demand growth and an inability to cut costs by relocating to low wage areas. MT products have grown mainly because of technical change and rising demand. Such products are not very susceptible to relocation for wage reasons. Even where relocation has taken place (e.g. the US auto industry to Mexico), it has gone to places with established industrial capabilities rather than just low wages. Most MT industries have complex, learning-intensive and linkage-dependent technologies, competitiveness depends vitally on local (technological and supplier) capabilities; it is not economical to shift processes over long distances to take advantage of cheaper unskilled or semi-skilled workers.

In HT products, by contrast, this *is* possible. While core processes remain highly complex, final assembly in several activities (particularly electronics) involves a lot of low skill labour. The product is sufficiently 'light' – high value-to-weight ratios – to make relocation of these processes economical while retaining complex processes in higher wage countries. Relocation adds to the dynamism of HT exports, reinforcing the effects of rapid innovation and rising demand. The growth of developing country HT exports reflects this dynamic interaction. Nevertheless, success in HT exports is highly concentrated in the developing world. Some of this success is due to the relocation of simple labour-intensive processes by TNCs, but some reflects the growth of indigenous enterprises and capabilities in manufacturing, designing and even innovating high-tech products. We return to these points below.

Figure 3: Shares of simple and complex products in dynamic exports



There is thus a strong *market positioning* argument for shifting export and production structures from low to high technology activities – as with a company, a country does better if its products are in fast-growing rather than market segments. Figure 3 shows the distribution over technological categories of ‘dynamic’ products in world trade, products whose exports are growing faster than the average for all products. The role of technologically ‘simple’ products (RB plus LT) has declined steadily over time; they now account for around one-third of world manufactured exports with the remaining two-thirds coming from medium and high technology products.[4] Of the latter group, a handful of high technology products (only 18 in number at the three-digit SITC level) account for around 55 per cent and their share has been rising over time. Trade in some low technology products has also grown rapidly; indeed, the growth of garment, footwear and toy exports has helped many developing countries. However, the growth impetus in such simple products is likely to diminish as the process of relocation matures and trade comes to match demand growth. In fact, the fashion cluster’s exports have been slowing down over time while HT exports are accelerating (Lall, 2000.a). More important, even if low technology exports grow, individual exporters may find it difficult to maintain growth as wages rise and production shifts to lower cost areas. Upgrading in terms of quality, design and technology tends to be more difficult in LT products than in HT products: no developing country has moved to top quality fashion garments but several have moved into frontier products in electronics.[5]

This is not, however, the only argument for upgrading technological composition in industry. The other and more powerful argument is that technology-intensive activities have *stronger development benefits.* They result in more sustained and deeper learning. They offer more prospects for continued productivity increase. They have more spillover benefits (by creating useful knowledge, skills and capabilities for other activities). Low technology activities do generate learning, but the stagnant technological base limits the learning that takes place. In most, like textiles, the skills and information generated have limited applicability to other activities. By contrast, technology intensive activities continuously apply science to production: their operation demands and creates more learning. Most create skills with applications to other industries. A low technology specialisation can therefore also become a low growth specialisation, besides being one with lower growth potential.[6]

[4] The dominance of technology intensive exports is greater in the group of the fifty most dynamic products in world trade. In 1995 MT and HT products accounted for 75 per cent of the value of exports of the fifty most dynamic exports over 1980-95, and HT for around 60 per cent of this subgroup. The top four fastest growing exports were all high-tech electronics products.

[5] The Malaysian case is illustrative. It is a strongly export-oriented country that started with low wages and both high and low technology activities, both led by foreign investors. In clothing, exports are stagnant and producers are relocating in lower wage areas while in electronics exports keep growing as new investors enter and existing ones upgrade their facilities.

[6] The case for structural change to capture dynamic growth and externality benefits is dealt with in the theoretical literature. See for instance Redding (1996) and Stokey (1991).

To conclude this section, the new technological paradigm affects all developing countries. It forces all productive activities to cope with emerging technologies, since they all have to compete by using new technologies in some form. The most advanced ones have to innovate constantly to retain a competitive edge, while backward ones have to develop new capabilities to use emerging technologies efficiently. Successful development thus entails a mixture of two things:

◊ Upgrading technologies, skills and productivity in existing activities (regardless of their technological level).

◊ Moving from technologically simple to complex activities (to improve market positioning and capture the development benefits of new technologies).

This process of technology upgrading has many requirements. Let us now consider its main drivers at the national level.

3. Drivers of technology development

3.1 Introduction: Firm level capabilities

This section deals with the 'drivers' of technology development at the national level. However, let us note at the start that it is not countries that generate technology. The main locus, creator and user of new technologies is the enterprise (Mowery and Rosenberg, 1989, Rosenberg *et al.* 1992). However, individual firms operate within a national context. This context provides the signals and incentives to undertake technological activity, the factor markets on which firms draw for information and inputs, and the social capital, institutions and rules that support business. Moreover, learning is not an individual activity. Firms learn from each other. The interactions inherent in learning are, in fact, so intense that analysts tend to think of national innovation or learning *systems* rather than of individual efforts.[7]

While neoclassical economics is the analytical base for current development policy, it does not provide a useful framework for analysing technical development. Much of it assumes, for instance, technology transfer and diffusion in developing countries to be relatively easy and automatic. Developing countries are technological followers that simply import and apply knowledge existing in more advanced economies. Technologies are transferred 'embodied' in new equipment, patents or blueprints. Their efficient *use* is, if

[7] The literature on 'national innovation systems' is mainly concerned with innovative activity (creating new products or processes) rather than with the more mundane technological learning that is the main concern of developing countries. As such, it has focused on industrialised or newly industrialising countries, and it has tended to be rather institutional in its approach. On the national innovation system approach see Lundvall (1992), Nelson (1993) and Edquist and McKelvey (2000). For the analysis of developing countries, we need a broader approach that also looks at strategic factors and market failures call for government intervention.

considered at all, taken as automatic and passive. Any intervention in the market-driven allocation of resources is thus assumed inefficient and distorting. Free trade and investment maximise flows of technology, then absorbed by a process of osmosis. Development strategies have to uniformly free market for all countries at all stages of development.

This approach to technology is seriously misleading, particularly when applied simplistically to major policy issues. To understand how firms actually become proficient in using technology, we turn to research on micro-level technical change (for a summary see Lall, 2000.b). This research, based on evolutionary theories of technical change (Nelson and Winter, 1982), shows why importing and mastering technologies in developing countries is not easy and automatic. Technology is not sold like physical products in fully embodied forms; nor does it flow by osmosis to agents exposed to advanced knowledge. It has important *tacit elements* that need effort to master. The process is generally slow, incremental and path dependent (Box 1). It often occurs in an uncertain environment where the skills, information, networks and credit needed are not available. Many enterprises do not how to go about learning. They have interact intensively with other agents; in the process they can lose the skills and knowledge they have accumulated (and gain by a similar process). All these features mean that technology development faces extensive coordination problems, externalities, missing markets and cumulative effects: all give rise to market failures (Stiglitz, 1996).

Box 1
Ten features of technological learning in developing countries

1. Technological learning is a real and significant process. It is conscious and purposive rather than automatic or passive. Firms using a given technology for similar periods need not be equally proficient: each would travel on a different learning curve according to the intensity and efficacy of its capability building efforts.
2. Firms do not have full information on technical alternatives. They function with imperfect, variable and rather hazy knowledge of technologies they are using.
3. Firms may not know how to build up the necessary capabilities — learning itself often has to be learned. The learning process faces risk, uncertainty and cost. For a technological latecomer, the fact that others have already undergone the learning process is both a benefit and a cost. It is a benefit in that they can borrow from the others' experience (to the extent this is accessible). It is a cost in that they are relatively inefficient during the process (and so have to bear a loss if they compete on open markets).
4. Firms cope with uncertainty not by maximising a well-defined function but by developing organisational and managerial satisficing routines (Nelson and Winter, 1982). These are adapted as firms collect new information, learn from experience and imitate other firms. Learning is path dependent and cumulative.
5. The learning process is highly technology specific, since technologies differ in their learning requirements. Some technologies are more embodied in equipment while others have greater tacit elements. Process technologies (like chemicals) are more embodied than engineering technologies (machinery or automobiles), and demand different (often less) effort. Capabilities built up in one activity are not easily transferable to another.
6. Different technologies have different spillover effects and potential for further technological advance. Specialisation in technologies with more technological potential and spillovers has greater dynamic benefits than specialisation in technologies with limited potential.
7. Capability building occurs at all levels — shop-floor, process or product engineering, quality management, maintenance, procurement, inventory control, outbound logistics and relations with other firms and institutions. Innovation in the sense of formal R&D is at one end of the spectrum of technological activity; it does not exhaust it. However, R&D becomes important as more complex technologies are used; some R&D is needed just for efficient absorption.

8. Technological development can take place to different depths. The attainment of a minimum level of operational capability (know-how) is essential to all activity. This may not lead to deeper capabilities, an understanding of the principles of the technology (know-why): this requires a discrete strategy to invest in deepening. The deeper the levels of technological capabilities aimed at, the higher the cost, risk and duration involved. The development of know-why allows firms to select better the technologies they need, lower the costs of buying those technologies, realise more value by adding their own knowledge, and to develop autonomous innovative capabilities.
9. Technological learning is rife with externalities and interlinkages. It is driven by links with suppliers of inputs or capital goods, competitors, customers, consultants, and technology suppliers. There are also important interactions are with firms in unrelated industries, technology institutes, extension services, universities, associations and training institutions. Where information flows are particularly dense, clusters emerge with collective learning for the group as a whole.
10. Technological interactions occur within a country and with other countries. Imported technology is generally the most important initial input into learning in developing countries. Since technologies change constantly, moreover, access to foreign sources of innovation is vital to continued technological progress. Technology import is not, however, a substitute for indigenous capability development — the efficacy with which imported technologies are used depends on local efforts to deepen the absorptive base. Similarly, not all modes of technology import are equally conducive to indigenous learning. Some come highly packaged with complementary factors, and so stimulate less learning.

Source: Lall (2000.b).

Learning to use new technologies, even those in existince elsewhere, needs investment by the user to create new skills, organisations, information and institutional support. In other words, ‘learning’ and ‘innovation’ activities differ not in kind but in degree (Lall, 1992). Both involve risk, effort and time. The diffusion of technologies plays a vital role in growth and competitiveness in industrial countries, where it also poses policy challenges (OECD, 1996). In developing countries, with weak enterprises, markets and institutions, it is far more difficult. Simply exposing firms in developing countries to international markets in the belief that free trade and investment will lead to technological learning may be very damaging. Firms may not be able to bear the costs involved in learning to compete with foreign firms that have undergone more learning or have better support networks. This is to some extent the story of the competitive failures of enterprises in Sub-Saharan Africa (below and Lall, ed., 1999).

Furthermore, mastering new technology is not a once-for-all task. It involves continuous *upgrading* and *deepening* of technologies, human capital and supporting networks. Without such continuous effort, countries can establish a competitive niche in a low technology activity but remain at the bottom of the technology ladder. Once wages rise such countries would lose their competitive edge in low wages for unskilled labour: development would be a self-defeating process as far as industry is concerned. To sustain development with rising wages, countries must move into more advanced technologies and technological functions. At each stage, learning needs new knowledge, skills and organisation – and so becomes more challenging. This has always been true, but the new technological paradigm means that the challenges become greater.

TECHNOLOGICAL FUNCTIONS AT THE FIRM LEVEL	Location of technological capabilities needed for implementation in industrialising economies	
TECHNOLOGY DEVELOPMENT	Domestic Economy	Other Economies

1. Continuous incremental, engineering-based improvement in production technology (both process technology and methods of organising production), contributing to increased competitiveness via higher productivity of both labour and capital, to greater efficiency in materials and energy use, and to higher product quality;	**☑**	
2. Continuous incremental improvement and diversification in product specifications and designs to help maintain shares in existing markets and to capture new higher value niches in both export and domestic markets;	**☑**	
3. Continuous improvement in the logistics technologies used to link different stages in value chains, involving both hardware (e.g. transport and computer-based systems) and organisational/management methods;	**☑**	☑
4. Design and (reverse) engineering activities that open up opportunities to source components, materials and equipment from local suppliers, or to diversify products and markets – either by existing firms or via new spin-out start-ups.	**☑**	
5. Technology search (and perhaps research) needed to lay the basis for effectively acquiring and absorbing advanced technologies close to the international frontier,	**☑**	☑
6. Technological research and development, plus the associated design and engineering required to introduce technologies that cannot be acquired (competitively) from foreign sources, and for introducing new products and processes that permit competitive entry to domestic or foreign markets independently of foreign technology sources.	**☑**	☑
TECHNOLOGY ACQUISITION		
7. Investment in new technology that is embodied in individual units of new machinery and equipment in existing industrial plants	☑	**☑**
8. The introduction of new materials and components incorporating existing designs and specifications	☑	**☑**
9. Investment in new technology that is embodied in complete new industrial production facilities: - as substantial additions to, or replacement of, production capacity in existing plants; or as totally new plants	☑	**☑**
10. The introduction of new product technology embodied in existing designs and specifications	☑	**☑**
Source: Bell (2000)		

The above table (taken from Bell, 2000) summarises ten basic categories of technological activity at the firm level. These fall into two groups. The second group (categories 7-10) involves the acquisition of new technology embodied in designs, specifications and machinery. The activities involved draw on the use of *existing* technology, mainly from the advanced industrial economies. However, in most newly industrialising economies some machinery or product designs may be locally available, along with engineering and project management capabilities required for implementation.

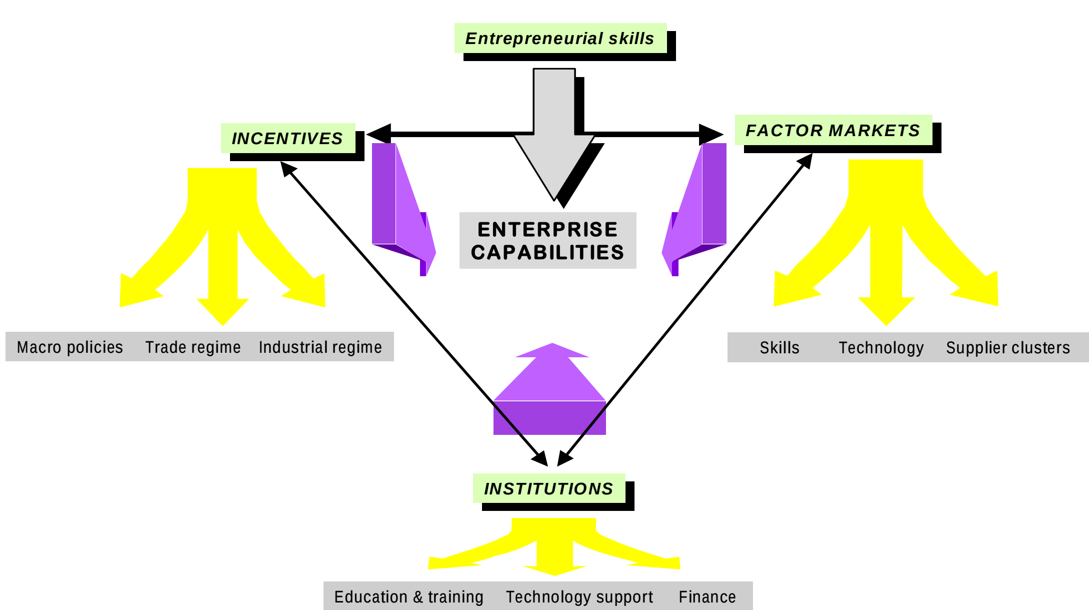
The other group of technological activities (categories 1-6) involves technology 'development', entailing local efforts and capabilities to generate and implement technical change. While it is possible to use foreign consultants and experts, and foreign knowledge and information are critical, the most important actors have to be domestic. Several of these activities involve a range of incremental improvements and modifications to technology already in use (categories 1-4). Some (categories 1 and 2) consist of activities to improve a firm's own technology, with positive consequences for that individual firm's competitiveness.

This summarises what *firms* do to master technology. Evolutionary theory suggests that the process is firm specific and differentiated. For policy purposes, however, we are not interested in firm-level differences and idiosyncrasies – what matters is the *general economic conditions* that promote firm-level learning and allow some countries to produce technically more competent firms than others. We have to draw a causal connection between internal learning processes and policy relevant variables. These include product markets (where firms sell output), factor markets (where firms obtain physical, service and knowledge inputs) and institutions (legal and regulatory systems as well as intermediate institutions like training or research bodies). This is considered now.

3.2 National systems of learning

What are the *elements of the economic system* in which firms invest in capability building? Many factors affect the decision of firms to invest in developing technological capabilities and the success of their investment. A simplified way of depicting them is to look at the *incentives* firms face to invest in capabilities, the *factor markets* they draw upon for their needs and the structure of *support institutions* relevant to capability building (Lall, 1992). There is, of course, a large random element related to individual enterprise or entrepreneurial characteristics, but we may ignore this in the analysis of national systems. The interacting **triad of incentives, factors** and **institutions** then comprises the system within which firms learn and create technology (Figure 4). The effectiveness of the system in promoting learning, and the depth and dynamism of the learning process, depend on how effectively each of the three sets of 'markets' operates.

Figure 4: Determinants of enterprise capability development



Note, however, that each can suffer from market failure. In this case, the *effectiveness of the national learning system depends on how well government policy overcomes the failure*. In this respect, the present approach differs from the national innovation systems approach, or from business school approaches (such as that of Porter, 1990) to competitiveness analyses. We place market and institutional failures in the centre of the picture, the others ignore it or assign it minor status.

Each determinant of competitiveness can be sub-divided into three. Under 'incentives' are macroeconomic management, trade policy (including transactions costs of trading), and industrial rules and regulations. Under 'factor markets' are skills, technology, and suppliers and interactions with competitors (clusters). Under 'institutions' are education and training, technology support, and financial institutions. Let us consider each in terms of policy implications.

Incentives: The main incentives affecting investment in learning arise from the *macroeconomic environment, trade policy, domestic industrial policies and domestic demand*. The importance of good <u>macro management</u> is so evident that it need not be discussed further. The role of <u>trade policies</u> is more complex. Participation in trade enables a country to realise its existing comparative advantage, and take advantage of scale economies where these arise. Facing world competition is an effective stimulus to building technological capabilities, and contact with world markets is an excellent, and free, source of technological information. The dangers of intervening in trade through prolonged and haphazard protection are also well known. 'Classic' import-substitution, with haphazard and open-ended protection for all activities with no regard to efficiency, clearly breeds inefficiency and technological sloth: export-orientation has been conclusively shown to be a better strategy.

It does not follow, however, that free trade (or sweeping liberalization when trade has been restricted) is optimal. Free markets cannot give correct signals for resource allocation in the presence of market failures arising from uncertain and unpredictable learning, variability by technology, increasing returns and widespread linkages (which also vary by activity). Thus, free markets can lead to under-investment in difficult technologies with high learning costs, exceptional risks, long learning periods and widespread externalities. These market failures arise both in *encouraging entry* by firms into 'difficult' and scale-intensive technologies and taking on more complex technological tasks, and in *coordinating* economic decisions by agents where there are externalities, linkages and economies of agglomeration and clustering. It follows that governments may have to intervene to restore efficient resource allocation, and that their interventions must vary by activity (according to the cost and risk of its learning and its externalities). Uniform support across activities in the presence of these technology-specific differences makes no sense — there are *good economic reasons for selectivity* in government interventions in trade policy.

Trade interventions can take the form of subsidies or protection. Economists prefer the former on theoretical grounds, governments prefer the latter on practical ones. Theory dictates that all such interventions should be carefully geared to remedying or taking advantage of market failures, and should be removed once the failures have been overcome (though the diffuse externalities inherent in technological development may never entirely disappear). They should not be of the haphazard, open-ended and non-selective sort typical in import substituting regimes. In the nature of the phenomenon, all such interventions are difficult to design: they require enormous information, are prone to rent-seeking behaviour, and can remove the incentive for the very learning they seek to promote. Difficult, but not impossible, since what is being sought is not one unique static optimum but a *range*, where the precise outcomes are not as important as the ability to stimulate a process of widespread and dynamic learning.

Governments have always intervened in free markets to promote industrial development, and their interventions have always been geared to technological learning. Early industrialisation in the presently developed countries is replete with industrial policy (Box 2). Recent development experience also provides examples of highly successful trade interventions. Note, however, that these are very different from the non-selective and uncoordinated interventions that took place under import substitution strategies, which were generally high cost and led to weak technology development. The examples of successful trade intervention come from East Asia and involved specific conditions.[8]

Box 2: Early industrialisation and strategy

The economics of development in the growth period of all the presently industrialised countries was 'economics without equilibrium' – a system where shifting clusters of disequilibrium-producing technical change provided growth. The goal of economic policy, mostly implicit, was a search for dynamic imperfect competition. The historical economic growth of nations was not a history of free trade or perfect markets. Even though historically natural protection in the form of very high transportation and information costs served as a natural deterrent to trade, tariffs and import and export prohibitions have been the most used tools of economic policy in history.

Towards the end of the 15th century England was a poor nation mainly producing wool for export, and heavily indebted to her Italian bankers. Over a relatively short period, however, it went from being a poor periphery of Europe to possessing an empire on which the sun never set. Its competitiveness increased enormously as production and exports rose and the standard of living improved, albeit very unevenly. This development was not the result of 'laissez faire'. It was based on a perception of the economic growth process very different from today's – economic growth was seen as *activity specific*, happening in some activities and not others. Increasing national wealth was tied to being active in 'good' activities.

The core of the English strategy is captured by the German economist Friedrich List's comment in 1841: 'The principle 'sell manufactured goods, buy raw materials' has during centuries been the substitute for a whole theory'. The industrial revolution can be seen as a process where, following woollen textiles, more and more processes were mechanised and more and more differentiated products appeared. The English picked up new industries in a period of transition from handicrafts to manufacturing industry: thus, they could descend learning curves faster than their later-starting competitors, achieve important economies of scale and learning-by-doing, and build significant barriers to entry for foreign competitors. By concentrating on manufacturing early in the industrial age the English created an unrivalled 'national innovation system' (Lundvall, 1992, Nelson, 1993).

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[8] These conditions are: strong leadership commitment to competitiveness, flexibility in policy making, skilled and insulated bureaucracy, supporting interventions in factor markets, close interaction with industry, and exposure to export competition (while retaining a protected domestic market to cushion learning) to discipline both firms and the government The World Bank (1993) documents some of these in the East Asian case, even though it comes out against selective trade interventions. Also see Stiglitz (1994, 1996), and for a critique of the Bank analysis Lall (1994).

Selling manufactures was regarded as 'good' trade even before the industrial revolution. In the late 15th century, King Henry VII undertook industrial policy to promote manufacturing: he 'secretly procured a great many Foreigners, who were perfectly skilled in the Manufacture, to come over and instruct his own People here in their Beginnings'. He gave subsidies to entrepreneurs, imposed import duties on textiles and high export duties on raw wool and, when English production capacity was sufficient, prohibited the export of raw wool altogether. Theories of 'good' and 'bad' trade were further refined in the 18th century by Charles King, essentially arguing that exporting raw materials to import finished manufactures was undesirable. In other words, industries characterised by perfect competition were less beneficial than those with imperfect competition.

The English emphasis on manufacturing consisted not only of promoting own manufacturing but also of stopping others from manufacturing where feasible. This involved, for instance, preventing the birth of manufacturing industry in the colonies. In some cases, it took the form of destroying foreign manufacturing to promote important English interests: prohibiting the prosperous Irish woollen textile industry in 1699, or demolishing the Bengali weaving industry in the early 19th century, are graphic examples. Strengthening the competitiveness of English industry was also attempted by preventing the emigration of skilled workers – a practice used by the Venetians earlier, under penalty of death – and by prohibiting the export of machinery from England until the 1830s.

Perhaps the best statement of the need for protection is by John Stuart Mill, the main 19th century proponent of free trade. Mill recognises clearly the existence of the uncertain and costly learning processes ignored by neoclassical economists. "The only case in which, on mere principles of political economy, protecting duties can be defensible, is when they are imposed temporarily (especially in a young and rising nation) in the hopes of naturalising a foreign industry, in itself perfectly suitable to the circumstances of the country. *The superiority of one country over another in a branch of production often arises only from having begun it sooner. There may be no inherent advantage on one part, or disadvantage in another, but only a present superiority of acquired skill and experience*... But it cannot be expected that individuals should, at their own risk, or rather to their certain loss, introduce a new manufacture, and *bear the burden of carrying on until the producers have been educated to the level of those with whom the processes are traditional*. A protective duty, continued for a reasonable time, might sometimes be the least inconvenient mode in which the nation can tax itself for the support of such an experiment."

In the USA, tariffs started to be used after 1819, a time when England had already abandoned protectionism and become a proponent of free trade. The involuntary protection enjoyed by the USA during the blockades on trade with Europe in 1812 had led to a minimum critical mass of manufacturing activity to provide a constituency for tariff protection. In 1920, Daniel Raymond provided a theoretical base for protection in his 'Thoughts on Political Economy'. He used the concept of 'productive capacity' to argue that some activities created much more productive capacity or power than others. The higher prices caused by protection would, he argued, be more than compensated by rising profits and wages – the result, in modern terminology, of technological learning, externalities and scale effects. The debate on protection in the USA reached huge proportions over the century, and tariffs fluctuated widely. Many analysts, including List during his stay there, saw it as a necessary temporary measure to catch up with England and then forge ahead. As Dorfman put it in 1947, 'free trade is the ideal, and the US will proclaim the true cosmopolitan principles when the time is ripe. This will be when the US has a hundred million people, when the seas are covered with her ships, when American industry attains the greatest perfection, and New York is the greatest commercial emporium and Philadelphia the greatest manufacturing city in the world. And when no earthly power can longer resist the American Stars, then our children's children will proclaim freedom of trade throughout the world, by land and sea'.

In Germany, List provided the theory that led to the unification of the nation and to industrial policy. List believed that nations must build 'productive power', which came from manufacturing not agriculture. He recommended abolishing internal tariffs in Germany and imposing external tariffs to realise scale economies and promoting national competencies. Japanese economic policy, both at the time of the Meiji restoration in 1868 and after the Second World War, was deliberately based on the German rather than the English model. It emphasised the importance of manufacturing over agriculture, and the need to build 'national productive power' by protection.

Source: adapted from Reinert (1995).

As far as <u>domestic industrial policies</u> are concerned, the removal of artificial barriers to competition provides the best stimulus to technological development. Thus, there is a critical role for anti-trust policies, elimination of artificial barriers to entry and protection of intellectual property rights. In fact, vibrant domestic competition is one of the best ways of offsetting some of the distortions that may be created by restricting import competition. However, the ideal is not necessarily the small, anonymous firm of textbook perfect competition models. Given the scale economies inherent in many industrial activities, particularly in advanced technology development, export marketing or investing overseas, it becomes desirable to promote large size that can allow firms to undertake and internalise the necessary investment and risk. This is just what some governments did to allow their industries to enter difficult technologies and develop advanced export and foreign investment capabilities, while promoting fierce domestic competition between the large firms and groups.

Domestic demand plays an important role in national capabilities, for two reasons. First, the 'quality' of local demand (the sophistication of buyers, the development of marketing channels, the intensity of competition) affects the development of advanced product, quality management and marketing skills (Porter, 1990). Second, the size of the domestic market influences the kinds of activities that can be undertaken. Some forms of technological learning require interacting with local markets (the greater costs involved in exporting mean that learning on export markets is not feasible). Thus, large countries can foster capabilities in more scale-intensive activities than smaller ones; since the effective size of the domestic market depends not only on total incomes but also its distribution, greater equity, with a broader base of demand, can be more conducive to the development of such capabilities.

Factor markets: The most important factor markets in technology development are *skills* (especially technical skills), *finance* for technological activity, and access to *information*, domestic and foreign.[9] The importance of skills, and the role of government in promoting education and training, is widely acknowledged — what should be noted is that policies to promote human capital for technology development become fairly *selective* at higher levels. At the start of the industrialisation process, the provision of literate labour may suffice for firms to be competitive. As technologies grow more demanding, firms need more advanced and specific technical, engineering and scientific skills. One of the most distinctive features of new technologies is their need for a broad range of technical skills as well as different kinds of skills that involve team work and multi-tasking. To the extent that the education and training systems fail to anticipate and provide for these needs, there is a need for selective interventions by the government.

Capital market failures in developing countries, arising from missing or asymmetric information and adverse selection, can lead to under-financing of risky or long gestating technological investments. Most capital market interventions take the form of directed and/or subsidised credit to selected clusters, industries or firms: all highly selective policies (which are generally integrated with trade and domestic industrial interventions). As with trade policies, most have not been efficient: but some Asian governments

[9] Physical infrastructure is vital, but this is obvious and need not be separately discussed here.

have used them effectively to promote industrial and technological development (Amsden, 1989, Wade, 1990, Stiglitz, 1996).

In *information markets*, access to foreign technology is vital to technology development, but the mode of access affects technological deepening. A passive reliance on foreign technologies, without interventions to ensure local effort to absorb and deepen them, may be sub-optimal. Interventions can take different forms: with *internalised* technology transfer, they can seek to guide FDI into more complex activities, induce existing foreign investments to upgrade the technological content of their activities, and/or promote the diffusion of technology and skills from foreign affiliates to local firms. Such selective interventions may coexist with non-interventionist policies in trade (e.g. Singapore, see below). With *externalised* forms, policies can stimulate greater absorption and deepening in local firms, by exposure to international markets, R&D incentives and support and entry into more complex technologies (e.g. Korea).

Several factor market interventions *have to be selective rather than functional*, for three reasons. First, several factor market needs are specific to particular activities; if they lack the information or coordination to meet these needs, interventions are needed to remedy these specific deficiencies. For instance, the skill needs of new electronics technologies may not be fully foreseen by education markets, or the financial needs emerging new technologies may not be addressed by capital markets. Second, the government's resources for supporting factor markets are limited, and to allocate among competing uses entails selectivity at a high level of priority setting (say, between education and other uses). Third, where the government is already targeting particular sectors for promotion in product markets, factor markets have to be geared to those objectives.

Institutions: 'Institutions' are used here in the narrow sense to refer to bodies that support industrial technology, such as education and training, standards, metrology, technical extension, R&D, long-term credit, technology and export information and so on. They may be government run, started by the government but run autonomously, or started and managed by industry associations or private interests. Many are set up on non-market terms, at least initially, in response to perceived gaps in the market provision of inputs. The catalytic role of government in launching many institutions is acknowledged, as is the fact that such interventions are often highly selective and geared to the objectives of industrial policy.

The outcome in terms of national technological capabilities depends on the complex interaction of these above variables on firm-level learning processes. However, *not all market failures call for government intervention*: markets may improve, private agents may remedy failures by non-market means, and the cost of intervention may outweigh its benefits. The risk of government failure, emphasised by neoliberal economists, is very real and needs to be addressed when selectivity is involved. The history of development is littered with well-intentioned but inefficient interventions. This being said, it remains true that where market failures or multiple equilibria exist, the outcome can be improved by appropriate policies. *That policies have been badly designed and implemented in the past is not a case against intervention as such. A general case against industrial policy can only be established if it is argued that intervention can never be better designed and implemented.* This cannot be established *a priori*. Ideological hostility to government apart, most would agree that this is an empirical, context and time-specific, matter.

3.3 Simplified list of drivers of technological learning

The best way to analyse the role of government in building technological capabilities is not to look at theory – since this provides relatively little guidance – but at the example of successful countries. Most analysts would agree that these are the mature Asian NIEs, in particular Singapore, Korea and Taiwan. The main tools their governments used for building local capabilities (to different extents and in different combinations, see Lall, 1996) were:

- *Trade policy and domestic credit policy to influence resource allocation*
- *Infrastructure development*
- *Firm size and cluster formation*
- *Skill development*
- *Technological activity and promotion*
- *FDI attraction, targeting or restriction*

Of these, the first three need not be discussed here further. The nature of industrial policy in East Asia is well known and debate on it continues (see Lall, 1996, Stiglitz, 1996, World Bank, 1993). However, the new 'rules of the game' of international trade and finance greatly limit the ability of countries to practise these forms of industrial policy today. Under WTO rules, import protection, local content rules and credit allocations are to be phased out completely. Infrastructure is too specialised a topic to be tackled here, though the significance for advanced modern transport and communications systems is obvious. Policies related to firm size and clusters are almost impossible to compare across large samples of developing countries.

What we can compare are the three main supply-side determinants of competitiveness: skill formation, technological activity and FDI. Even here, the comparisons are subject to several difficulties and qualifications but at least some useful conclusions can be drawn for this report. Before we come to the comparisons, however, we look at the diverging trends among developing countries in terms of technological performance.

4. Building competitive capabilities: diverging patterns

4.1 Indicators of diverging technological performance

We use manufactured exports as a convenient indicator of technological performance, with the technology composition of export products serving as a proxy for upgrading over time. We noted earlier that while the developing world as a whole appears to be doing very well in terms of competing in manufactured exports and upgrading the technology structure of its exports, success was highly uneven. Not only was export competitiveness highly concentrated among a few countries and regions, the divergence between successful countries and others appeared to be growing over time. Let us now see some evidence on this (all the data are from Lall, 2000.a).

Table 2 shows regional shares of manufactured exports by technological categories in the developing world. This shows clearly that export success is highly concentrated and that there is increasing divergence between strong and weak performers. East Asia dominates all manufactured exports and all categories apart from resource-based products. Its share is growing in all categories except for LT; in *HT, it commands over 85%*. The other outstanding performer is Mexico, with NAFTA driving rapid export growth in all categories; the rest of Latin America does rather poorly despite massive liberalization. Sub-Saharan Africa is practically absent, with the minor exception of RB products – even here, it has a tiny presence despite its strong resource base. Again, such liberalization as has taken place has done nothing to its export dynamism.

Table 2: Regional shares of developing countries' manufactured exports (% of developing world total)[10]

	Year	East Asia	South Asia	MENA	LAC1 incl. Mexico	LAC2 exc. Mexico	Mexico	SSA 1 incl. S Africa	SSA 2 exc. S Africa
All	1985	56.9	4.5	12.9	23.1	16.9	6.2	N/A	2.6
Manufactures	1998	69.0	3.8	6.0	19.3	8.9	10.4	1.8	0.8
RB	1985	34.6	3.8	23.8	32.9	30.7	2.2	N/A	4.9
	1998	47.5	4.7	15.0	28.0	24.0	4.0	4.8	1.4
Agro based	1985	*55.1*	*2.2*	*4.5*	*32.0*	*30.4*	*1.6*	*N/A*	*6.2*
	1998	*55.1*	*1.7*	*4.9*	*33.1*	*28.3*	*4.6*	*5.3*	*2.4*
Other RB	1985	*25.6*	*4.5*	*32.3*	*33.3*	*30.8*	*2.5*	*N/A*	*4.3*
	1998	*41.4*	*7.2*	*23.1*	*23.1*	*20.6*	*2.5*	*4.4*	*0.6*
LT	1985	71.7	8.3	7.3	11.9	10.2	1.7	N/A	1.8
	1998	70.2	8.5	7.2	12.6	5.4	7.2	1.5	0.2
Textile cluster	1985	*69.9*	*11.6*	*8.1*	*9.5*	*8.5*	*1.0*	*N/A*	*0.9*

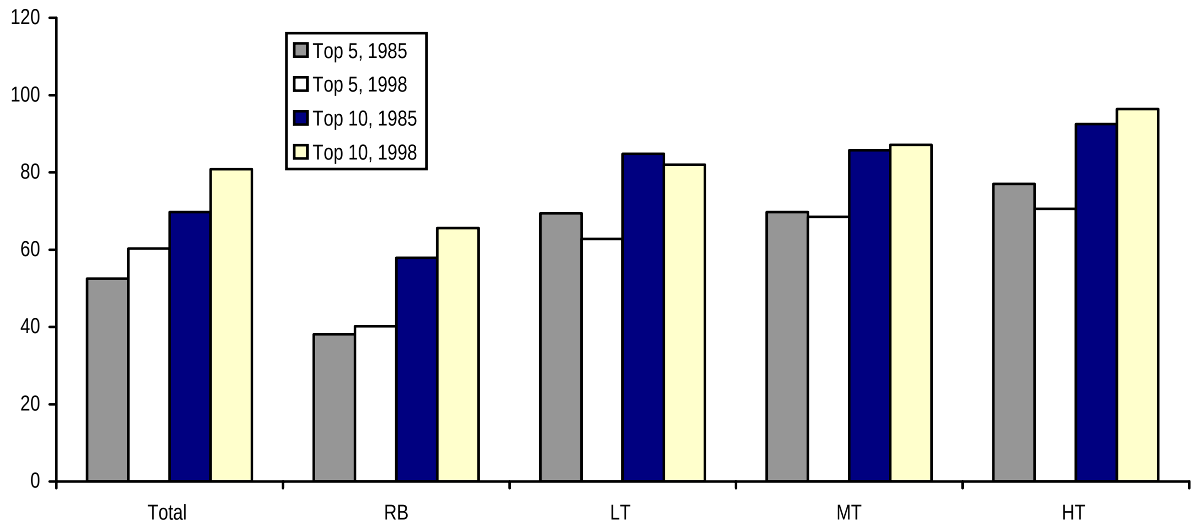
[10] 'East Asia' includes all countries in Asia east of Myanmar, including Myanmar and Vietnam (but not Laos or Cambodia for lack of reported data) and China, and excludes Japan and Central Asian transition countries. 'South Asia' comprises India, Pakistan, Bangladesh, Sri Lanka, Maldives, Nepal and Bhutan. 'MENA' (Middle East and North Africa) includes Afghanistan and Turkey as well as all Arab countries (Sudan is counted under SSA). 'SSA' (Sub-Saharan Africa) includes South Africa (SSA1) unless specified (SSA2). 'LAC' (Latin America and the Caribbean) includes Mexico (LAC1) and excludes it (LAC2) when specified.

	1998	*67.3*	*12.1*	*9.1*	*10.4*	*4.9*	*5.5*	*1.1*	*0.8*
Other LT	1985	*75.2*	*1.7*	*5.7*	*16.6*	*13.5*	*3.1*	*N/A*	*0.8*
	1998	*74.9*	*2.9*	*4.2*	*16.0*	*6.3*	*9.7*	*2.0*	*0.3*
MT	1985	63.4	2.0	7.1	25.8	17.5	8.3	N/A	1.8
	1998	63.8	1.8	4.4	28.1	10.2	17.9	1.9	0.2
Auto	1985	*40.6*	*2.7*	*5.9*	*50.3*	*32.9*	*17.4*	*N/A*	*0.4*
	1998	*39.8*	*1.4*	*2.9*	*54.2*	*16.9*	*37.3*	*1.7*	*0.1*
Process	1985	*53.4*	*2.3*	*13.8*	*28.2*	*25.2*	*3.0*	*N/A*	*2.3*
	1998	*65.6*	*3.3*	*8.4*	*19.9*	*13.0*	*6.9*	*2.8*	*0.5*
Engineering	1985	*73.0*	*1.7*	*3.5*	*20.1*	*10.4*	*9.7*	*N/A*	*1.7*
	1998	*72.5*	*1.1*	*2.6*	*22.4*	*5.8*	*16.6*	*1.3*	*0.1*
HT	1985	81.0	1.1	1.8	14.8	6.6	8.2	N/A	1.3
	1998	85.5	0.6	0.7	12.9	2.1	10.8	0.4	0.0
Electronic	1985	*84.7*	*0.5*	*0.7*	*14.0*	*5.1*	*8.9*	*N/A*	*0.1*
	1998	*87.2*	*0.3*	*0.6*	*11.8*	*1.2*	*10.6*	*0.2*	*0.1*
Other HT	1985	*60.3*	*4.5*	*8.2*	*19.2*	*15.2*	*4.0*	*N/A*	*7.8*
	1998	*66.9*	*4.2*	*1.9*	*25.0*	*12.2*	*12.8*	*0.0*	*0.3*

Source: Lall (2000.a). For the composition of the regional groups see footnote 10.

Exports by developing countries are concentrated not just regionally but – to a surprising extent – also nationally. Figure 5 shows the shares of the top 5 and 10 exporting countries in the developing world.

Figure 5: Shares of top 5 & 10 exporters in developing country mfd. exports, 1985 and 1998 (%)



Three features deserve comment:

◊ Overall concentration is very high: in 1998, 5 countries accounted for 60% and 10 for over 80%, of total manufactured exports by developing countries .

◊ Concentration rises with technological sophistication, reaching 96% for the leading 10 HT exporters in 1998.

Table 3: Distribution of manufactured exports over technological categories, 1985 and 1998.

1985	RB	RB 1	RB 2	LT	LT 1	LT 2	MT	MT 1	MT 2	MT 3	HT	HT 1	HT 2
World	23.7%	9.8%	13.8%	18.6%	8.3%	10.3%	40.9%	12.2%	9.7%	19.0%	16.8%	10.9%	5.9%
Developed	21.0%	9.6%	11.5%	16.1%	5.8%	10.3%	44.7%	14.3%	10.3%	20.1%	18.2%	11.4%	6.8%
Developing	38.0%	11.6%	26.5%	30.4%	20.1%	10.3%	20.6%	2.1%	6.7%	11.9%	11.0%	9.3%	1.7%
East Asia	23.1%	11.2%	11.9%	38.3%	24.7%	13.6%	23.0%	1.5%	6.3%	15.2%	15.6%	13.8%	1.8%
South Asia	32.3%	5.6%	26.7%	55.8%	51.8%	4.0%	9.2%	1.3%	3.4%	4.5%	2.8%	1.1%	1.7%
MENA	70.1%	4.0%	66.1%	17.1%	12.6%	4.5%	11.3%	1.0%	7.1%	3.2%	1.6%	0.5%	1.1%
LAC 1	54.2%	16.1%	38.2%	15.7%	8.3%	7.4%	23.1%	4.5%	8.2%	10.4%	7.0%	5.6%	1.4%
LAC 2	61.1%	18.4%	42.7%	16.2%	8.9%	7.3%	18.9%	3.6%	8.8%	6.5%	3.8%	2.5%	1.3%
SSA 2	70.7%	27.3%	43.3%	10.1%	7.0%	3.0%	13.8%	0.3%	5.9%	7.6%	5.5%	0.5%	5.0%
1998	**RB**	**RB 1**	**RB 2**	**LT**	**LT 1**	**LT 2**	**MT**	**MT 1**	**MT 2**	**MT 3**	**HT**	**HT 1**	**HT 2**
World	17.3%	8.9%	8.4%	18.8%	8.2%	10.6%	38.9%	11.5%	8.8%	18.6%	25.1%	18.2%	6.9%
Developed	16.8%	9.1%	7.7%	15.5%	5.2%	10.2%	43.2%	13.6%	9.1%	20.5%	24.5%	16.0%	8.5%
Developing	17.6%	7.8%	9.8%	27.8%	17.1%	10.8%	25.5%	5.2%	7.6%	12.8%	29.1%	26.6%	2.5%
East Asia	12.1%	6.2%	5.9%	28.3%	16.6%	11.7%	23.6%	3.0%	7.2%	13.4%	36.0%	33.6%	2.4%
South Asia	21.7%	3.4%	18.3%	61.6%	53.6%	8.0%	12.1%	1.9%	6.5%	3.7%	4.6%	1.9%	2.8%
MENA	44.3%	6.4%	37.9%	33.7%	26.1%	7.6%	18.8%	2.5%	10.6%	5.7%	3.3%	2.5%	0.8%
LAC 1	25.4%	13.3%	12.1%	18.1%	9.1%	8.9%	37.1%	14.5%	7.8%	14.8%	19.4%	16.2%	3.2%
LAC 2	47.2%	24.5%	22.6%	16.8%	9.3%	7.5%	29.1%	9.8%	11.0%	8.3%	6.9%	3.5%	3.4%
SSA 1	46.0%	22.4%	23.6%	22.6%	10.5%	12.0%	25.8%	4.9%	11.6%	9.3%	5.7%	3.0%	2.7%
SSA 2	51.3%	38.6%	12.7%	35.0%	27.4%	7.6%	11.5%	0.6%	7.7%	3.2%	2.2%	0.7%	1.5%

Source: As Table 2. SSA1 does not appear for 1985 because data for South Africa are not available.

◊ Concentration tends to rise over time. This suggests that entry barriers are rising: the *ability to compete* is not growing in response to liberalization.

The rise in concentration is not universal. The figures shows small exceptions in LT products at both 5 and 10 country levels and MT and HT products at the 5 country levels. However, more detailed data show that even in LT products, concentration rises at the 13-country level, and in MT and HT it rises at both 10 and 13 country levels. There are some changes in position among the leaders but growth for 'outsiders' still seems to have become more rather than less difficult.

Let us now compare the technological composition of exports by different regions (Table 3). The world as a whole and the developed countries shift from RB to HT products. In the developing world, there is a more marked shift away for 'simple' (RB and LT) to 'complex' (MT and HT) products, but with a massive increase in HT. As expected, East Asia has the most high-tech export structure (more than developed countries) and the most pronounced upgrading; its reliance on LT products falls over time, particularly in the textile group. LAC also has a complex structure but mainly because of MT products (particularly autos); the Mexican presence is very significant, but even without it the region's exports retain a large weight of process industries and RB products.

Both MENA and SSA2 reduce their heavy dependence on RB, but remain specialised in simple manufactured products by raising their reliance on LT, especially in the textile cluster (Turkey and

Table 4: RCAs by technological categories in developing regions, 1985 and 1998

	Primary 85	Primary 98	RB 85	RB 98	LT 85	LT 98	MT 85	MT 98	HT 85	HT98
Developed countries	0.641	0.735	1.000	1.003	0.973	0.852	1.232	1.150	1.215	1.009
Developing countries	2.147	1.590	1.081	0.949	1.098	1.384	0.340	0.613	0.439	1.083
East Asia	1.132	0.643	0.892	0.742	1.880	1.601	0.514	0.644	0.848	1.524
South Asia	1.441	1.453	1.245	1.216	2.737	3.180	0.205	0.301	0.150	0.178
MENA	3.368	4.973	1.074	1.242	0.333	0.869	0.1000	0.234	0.034	0.063
LAC 1	2.289	2.305	1.523	1.232	0.560	0.806	0.375	0.799	0.277	0.647
LAC 2	2.163	3.309	1.824	1.850	0.128	0.607	0.326	0.507	0.160	0.186
SSA 1	-	3.028	-	1.786	-	0.806	-	0.446	-	0.151
SSA 2	3.779	5.250	0.704	1.365	0.128	0.855	0.080	0.136	0.077	0.040

Source: as Table 2.

Morocco in MENA and Mauritius in SSA2). However, MENA raises its reliance on HT and MT slightly, while SSA2 does the reverse. South Asia shows a similar trend to MENA, but with a much heavier reliance on LT products.

The regions' relative export strengths show up more clearly in their '*revealed comparative advantage*' (RCA) indices (Table 4).[11] RCAs for the developed world are remarkably stable over time, with slight rises in primary and RB products and falls in the other categories (including HT). There is more alteration in the developing world, with primary and RB products losing their advantage and the largest increase coming in HT. East Asia leads the developing world's push up the technology ladder, with some support from LAC1 (i.e. Mexico). East Asia's 1998 RCA in HT exceeds that of developed countries as a whole, and slightly lags its RCA in LT products. Its lowest RCAs are in primary and MT products; it is the only developing region with a revealed comparative disadvantage in primary products and the only one for which this figure is lower in 1998 than 1985.

The highest RCAs for South Asia are in LT and primary products, with RB close to the latter; its lowest are in HT. The region has the highest revealed advantage in LT, bearing out its heavy dependence on textile-related exports and its slow upgrading. SSA2, MENA and LAC show strong advantages in primary and RB products; while the latter two show some improvement in RCAs in HT products, SSA2 regresses over the period.

In sum, industrial export competitiveness in the developing world is highly concentrated over the entire technological spectrum but concentration rises with technology levels. This uneven distribution cannot be accounted for differences in trade or investment policies, but is traceable to the process of building technological and other capabilities. A few developing countries have built the capabilities to export technologically complex products and have been extremely successful in global competition. Others

[11] RCAs measure the world market share of a given exporter in a particular product or product group relative to its market share for all products.

have not, and of these many are threatened by effective marginalisation from the mainstream of global economic activity and technology development.

However, the successful countries have not had uniform strategies. We can distinguish at least four main sets of strategies, each with different policy instruments and implications:

- *'Autonomous'*, based on the development of capabilities in domestic firms, starting in simple activities and deepening rapidly over time. This used extensive industrial policy, reaching into trade, finance, education, training, technology and industrial structure. It involved selective restrictions on FDI and actively encouraged technology imports in other forms. All these interventions were carried out in a strongly export-oriented setting, with favours granted in return for good export performance. The prime examples are Korea and Taiwan.
- *'Strategic FDI dependent'*, driven by FDI and with strong efforts to upgrade TNC activity, directing investments into higher value-added activities and inducing existing affiliates to upgrade their technologies and functions. This strategy involved extensive interventions in factor markets (skill creation, institution building, infrastructure development and supplier support), encouraging R&D and technology institutions, and in attracting, targeting and guiding investments. The best example is Singapore.
- *'Passive FDI dependent'*, also driven by FDI but relying largely on market forces to upgrade the structure (with rising wages and growing capabilities). The main tools were a welcoming FDI regime, strong incentives for exports, with good export infrastructure, and cheap, trainable labour. Skill upgrading and domestic technological activity were relatively neglected (though some countries had a relatively good base), and the domestic industrial sector tended to develop in isolation from the export sector. Malaysia, Thailand and Philippines are good examples, as are the Special Economic Zones of China and the *maquilas* of Mexico.
- *'ISI restructuring'*, with exports growing from long-established import-substituting industries where competitive (or nearly competitive) capabilities had developed. The main policy tool was trade liberalization or strong export incentives (some within regional trade agreements). This led to considerable upgrading, restructuring and expansion along with supplier networks. In some countries the agents were domestic enterprises, in others TNCs. The main difference from the 'autonomous' strategy is the lack of clear, coordinated industrial policy to develop competitiveness, with haphazard (generally weak) support for skills, technology, institutions and infrastructure. China and India are examples within Asia, the large Latin American economies elsewhere; elements of this strategy are also present in many other economies.

These strategies are not mutually exclusive. Countries have combined them and varied the combinations over time. There does not, in other words, appear to an optimal strategy for all developing countries at all times. Different approaches have to be adapted to differing initial conditions, political economies and strategic 'visions'. The common strategic issue for all countries is to address the market failures affecting the main drivers of technology development: skills, technological effort, support institutions, information flows, agglomeration and FDI.

We now consider evidence on how countries have done this. Again, we find, despite some convergence of policies in terms of liberalization, growing divergence between regions and countries, with the patterns closely matching those revealed by the competitiveness data.

4.2 Skill formation

Skills are rightly considered one of the most important ingredients of technology development. It is rising in significance as technology changes more rapidly and gains greater information content (ILO, 1998). For instance, about fifty per cent of the value of a new car now lies in its 'information content' – design, process management, marketing, sales and so on. As *The Economist* noted, "over three-quarters of the value of a typical manufactured product is already contributed by service activities such as design, sales and advertising."[12] The general rise in the share in economic activity of *high value services* – finance, communications, transportation and servicing – greatly strengthens this trend (Quah, 1999).

Apart from the obvious need for skills to actually create and manage new technologies, new skills are also entailed in *new functions* and forms of *work organisation*. In many cases, new skills have to be complemented with other changes: different attitudes to work, new occupational categories, new work relationships and new management systems. Consequently, the education and training system has to upgrade skills constantly in line with emerging needs. Thus, "the demand for professionals and technicians has increased in all countries, as their analytical, cognitive and behavioural skills equip them better to adapt to more sophisticated technology. However, even within these high-skilled jobs the trend is increasingly towards multi-skilling – combining specialised professional expertise with business and management skills… [Even for production workers] the trend is towards up-skilling and multi-skilling. A study of 56,000 production workers over an eight-year period shows that skill requirements in production jobs have changed… It is not only that each job has experienced up-skilling, the overall distribution of production jobs has shifted from the less to the more skilled." (ILO, 1998, p. 47)

[12] *The Economist*, 'World Economy Survey', September 28, 1996, p. 48.

Skills arise from a variety of sources: formal education, vocational training, in-firm training, specialized employee training outside the firm, and learning on the job. The relative importance of these sources varies by economic structure, the nature of knowledge being utilised and the level of development. Basic schooling and literacy may be sufficient to absorb simple industrial technologies (though even these require a complement of some high level technical and managerial manpower). Advanced schooling and tertiary education become important as more complex knowledge is tackled. Sophisticated modern technologies require high levels of numeracy and a broad base of skills on the shopfloor. They also need a high proportion of technical personnel. Among these, the role of engineers merits particular attention.

It is difficult to compare skill formation across countries. For reasons mentioned above, informal skill creation on the job is difficult to measure at the enterprise level – and impossible to quantify at the national level. Data on enterprise training are patchy and incomplete (though its significance is reviewed below). The available data only allow us to compare enrolments across countries for similar levels of formal education. This also has problems. The definitions of education levels are not uniform. The quality of education at similar levels differs greatly, as does the relevance of the curriculum. Enrolment rates do not show differences in completion rates. Nevertheless, enrolment data are available on a comparable basis, and the rates reveal something about the *base* for skill acquisition.

Table 5 shows broad enrolment data for the main groups of countries, including developed and transition economies (note that the regional rates are simple averages, not weighted by population). Enrolment rates have risen in all regions. However, they show large disparities, mirroring those shown earlier in export performance. Sub-Saharan Africa lags at all, particularly the tertiary, levels of education. The four mature Asian Tigers lead the developing world at higher levels, just slightly behind developed economies. The four new Tigers, Latin America and Middle East/North Africa are roughly similar in their secondary and tertiary level enrolments, just behind the levels reached in the transition economies. South Asia and China have low levels of tertiary enrolment, but China is considerably stronger at the secondary level. To the extent that these simple indicators of skill formation are valid, they show large gaps in the education base for competitiveness.

Table 5: Enrolment Ratios (percentage of age groups)

Mean for group (unweighted)	Enrolment Ratios (1980)			Enrolment Ratios (1995)		
	1 level	2 level	3 level	1 level	2 level	3 level
Developing countries	88	34	7	91	44	11
Sub-Saharan Africa	74	17	1.3	78	23	2.9
MENA	88	42	9.7	92	59	14.3
Latin America	102	45	14.1	103	53	18.1
Asia	95	44	7.4	99	54	14.4
4 Tigers	106	72	13.0	100	82	36.4
4 new Tigers	103	43	12.3	102	60	17.3
S Asia	75	28	4.0	93	42	4.8
China	112	46	1.3	120	69	5.7

Others	96	37	3.7	98	35	5.9
Transition economies	100	77	14.6	95	76	22.2
Developed Economies	102	84	27.2	104	113	50.6
Europe	101	82	24.5	104	113	44.6
N America	101	91	49.1	102	102	92.0
Japan	101	93	30.5	102	99	40.3
Austr/N Zealand	111	84	27.0	106	132	65.0

Source: Calculated from UNESCO, *Statistical Yearbooks*, various.

As noted, these figures conceal differences in completion rates, quality and relevance. While we cannot correct for these, look at one indicator of school quality: the TIMSS (Third International Mathematics and Science Study) scores for 8th Grade students (Table 6). Of the 41 countries in which half a million 13 year olds were tested, Singapore reached first place in both mathematics and science; Korea came second in mathematics and fourth in science; Hong Kong came fourth in mathematics and 24th in science. Japan was the best of the developed countries, coming third in both. Of other developing countries, Thailand was half way down in both, while Iran did poorly in science but better than Thailand in mathematics. Kuwait, Colombia and South Africa took the last three places in both subjects. While most developing countries are not in the test, it would not be surprising if the quality ranking was similar to the enrolment rates, with East Asia coming on top and Sub-Saharan Africa at the bottom.

Table 6: Grade 8 TIMSS Assessment, 1994-95 (overall mean)

Science		Mathematics	
All countries	516	All countries	513
Singapore	607	Singapore	643
Czech Republic	574	South Korea	607
Japan	571	Japan	605
Bulgaria	565	Hong Kong	588
South Korea	565	Belgium (Flemish)	565
Netherlands	560	Czech Republic	564
Slovenia	560	Slovak Republic	547
Austria	558	Switzerland	545
Hungary	554	Netherlands	541
England, Wales	552	Slovenia	541
Belgium (Flemish)	550	Bulgaria	540
Australia	545	Austria	539
Slovak Republic	544	France	538
Ireland	538	Hungary	537
Russian Federation	538	Russian Federation	535
Sweden	535	Australia	530
United States	534	Iran	528
Canada	531	Canada	527
Norway	527	Ireland	527
New Zealand	525	Belgium (French)	526
Thailand	525	Israel	522
Israel	524	Thailand	522

Hong Kong	522	Sweden	519
Switzerland	522	Germany	509
Scotland	517	New Zealand	508
Spain	517	England, Wales	506
France	498	Norway	503
Greece	497	Denmark	502
Iceland	494	United States	500
Romania	486	Scotland	498
Latvia	485	Latvia	493
Portugal	480	Iceland	487
Denmark	478	Spain	487
Lithuania	476	Greece	484
Belgium (French)	471	Romania	482
Iran	470	Lithuania	477
Cyprus	463	Cyprus	474
Germany	431	Portugal	454
Kuwait	430	Kuwait	392
Colombia	411	Colombia	385
South Africa	326	South Africa	354

Source: National Science Foundation, 1998.

The breakdown of *tertiary enrolments in technical subjects* may be more relevant than general enrolments for assessing capabilities to absorb technological knowledge, and of this, enrolments in engineering is probably the most significant. Table 7 shows numbers enrolled in tertiary education and in the three main technical subjects (science, mathematics/computing and engineering) in 1995, with averages weighted by population. These figures show wider dispersion than general enrolment rates. The Asian NIEs enrol 33 times the proportion of population in technical subjects than Sub-Saharan Africa (even including South Africa). The ratio is twice that of industrial countries, nearly 5 times Latin America and the new NIEs, and over 10 times South Asia and China. The leading 3 countries in terms of total technical enrolments account for 44 percent of the developing world's technical enrolments: China (18%), India (16%) and Korea (11%). The top ten account for 76 percent and the top 20 for 93 percent.

Table 8: Tertiary level enrolments and enrolments in technical subjects (1995)

	Total 3 level enrolment		*Technical enrolments, numbers & % of population*							
	All subjects		*Natural Science*		*Math's, computing*		*Engineering*		*All Technical subjects*	
	Numbers	*% pop.*	*numbers*	*%*	*numbers*	*%*	*numbers*	*%*	*numbers*	*%*
Developing countries	*35,345,800*	*0.82%*	*2,046,566*	*0.05%*	*780,930*	*0.02%*	*4,194,433*	*0.10%*	*7,021,929*	*0.16%*
Sub-Saharan Africa	1,542,700	0.28%	111,500	0.02%	39,330	0.01%	69,830	0.01%	220,660	0.04%
MENA	4,571,900	1.26%	209,065	0.06%	114,200	0.03%	489,302	0.14%	812,567	0.22%
Latin America	7,677,800	1.64%	212,901	0.05%	188,800	0.04%	1,002,701	0.21%	1,404,402	0.30%
Asia	21,553,400	0.72%	1,513,100	0.05%	438,600	0.01%	2,632,600	0.09%	4,584,300	0.15%
4 Tigers	3,031,400	4.00%	195,200	0.26%	34,200	0.05%	786,100	1.04%	1,015,500	1.34%
4 new Tigers	5,547,900	1.61%	83,600	0.02%	280,700	0.08%	591,000	0.17%	955,300	0.28%
S Asia	6,545,800	0.54%	996,200	0.08%	7,800	0.00%	272,600	0.02%	1,276,600	0.10%
China	5,826,600	0.60%	167,700	0.02%	99,400	0.01%	971,000	0.10%	1,238,100	0.13%

Others	601,700	0.46%	70,400	0.05%	16,500	0.01%	11,900	0.01%	98,800	0.08%
Transition economies	*2,025,800*	*1.95%*	*55,500*	*0.05%*	*30,600*	*0.03%*	*354,700*	*0.34%*	*440,800*	*0.42%*
Developed countries	*33,774,800*	*4.06%*	*1,509,334*	*0.18%*	*1,053,913*	*0.13%*	*3,191,172*	*0.38%*	*5,754,419*	*0.69%*
Europe	12,297,400	3.17%	876,734	0.23%	448,113	0.12%	1,363,772	0.35%	2,688,619	0.69%
N America	16,430,800	5.54%	543,600	0.18%	577,900	0.19%	904,600	0.31%	2,026,100	0.68%
Japan	3,917,700	0.49%					805,800	0.10%	805,800	0.10%
Australia, NZ	1,128,900	5.27%	89,000	0.42%	27,900	0.13%	117,000	0.55%	233,900	1.09%
Source: Calculated from UNESCO (1997) and national sources										

The creation of high level technical skills – the skills most directly relevant for using new technologies effectively – is thus highly unevenly distributed across the world. It is also very skewed *within* the developing world. Table 8 shows the global ranking of countries (developed and developing) by tertiary enrolments in technical subjects as a percentage of the population. Korea leads not just developing countries but the world as a whole, with Taiwan Province the next among developing countries. At the other end, Sub-Saharan Africa provides most of the laggards. Even an impressionistic reading of the table shows a clear correlation between industrial success and human capital formation.

Table 8: Countries ranked by % of technical tertiary enrolments in population, 1995

Rank	Country	% enrolment	Rank	Country	% enrolment
1	Korea, Republic of	1.65%	61	El Salvador	0.27%
2	Finland	1.33%	62	Morocco	0.25%
3	Australia	1.17%	63	Tunisia	0.24%
4	Russian Federation	1.16%	64	Indonesia	0.23%
5	Taiwan Province	1.07%	65	Nicaragua	0.22%
6	Spain	0.97%	66	Honduras	0.20%
7	Ireland	0.91%	67	Myanmar	0.20%
8	Austria	0.78%	68	Syria	0.20%
9	Germany	0.77%	69	Cuba	0.19%
10	UK	0.75%	70	Thailand	0.19%
11	Portugal	0.73%	71	Brazil	0.18%
12	Sweden	0.73%	72	South Africa	0.17%
13	Chile	0.73%	73	Hungary	0.16%
14	Ukraine	0.72%	74	Trinidad & Tobago	0.14%
15	Greece	0.72%	75	Malaysia	0.13%
16	Canada	0.69%	76	Saudi Arabia	0.12%
17	Slovakia	0.68%	77	Egypt	0.12%
18	USA	0.68%	78	India	0.12%
19	New Zealand	0.68%	79	Paraguay	0.11%
20	Israel	0.68%	80	Jamaica	0.11%
21	Norway	0.67%	81	Albania	0.11%
22	Bulgaria	0.67%	82	China	0.10%
23	Japan	0.64%	83	Côte d'Ivoire	0.09%
24	Italy	0.64%	84	Zimbabwe	0.09%
25	Estonia	0.63%	85	Sri Lanka	0.09%
26	France	0.61%	86	Botswana	0.08%
27	Denmark	0.60%	87	Nepal	0.08%
28	Panama	0.59%	88	Bangladesh	0.08%
29	Netherlands	0.56%	89	Cameroon	0.06%
30	Philippines	0.55%	90	Madagascar	0.06%

31	Yugoslavia	0.52%	91	Nigeria	0.06%
32	Croatia	0.52%	92	United Arab Emir.	0.05%
33	Switzerland	0.51%	93	Senegal	0.05%
34	Colombia	0.51%	94	Pakistan	0.05%
35	Slovenia	0.51%	95	Mauritius	0.05%
36	Hong Kong	0.49%	96	Congo	0.04%
37	Romania	0.49%	97	Oman	0.04%
38	Singapore[13]	0.47%	98	Benin	0.04%
39	Argentina	0.47%	99	Namibia	0.03%
40	Belarus	0.47%	100	Mauritania	0.03%
41	Czech Republic	0.46%	101	Togo	0.03%
42	Peru	0.46%	102	Lesotho	0.03%
43	Iran	0.45%	103	Sudan	0.03%
44	Mexico	0.44%	104	Yemen	0.02%
45	Belgium	0.43%	105	PNG	0.02%
46	Yugoslavian Macedonia	0.43%	106	Eritrea	0.02%
47	Jordan	0.42%	107	Laos	0.02%
48	Algeria	0.41%	108	Kenya	0.02%
49	Lithuania	0.40%	109	Burkina Faso	0.02%
50	Lebanon	0.40%	110	Uganda	0.01%
51	Poland	0.39%	111	Burundi	0.01%
52	Kuwait	0.39%	112	Mozambique	0.01%
53	Moldova	0.35%	113	Ghana	0.01%
54	Costa Rica	0.35%	114	CAR	0.01%
55	Bolivia	0.34%	115	Ethiopia	0.01%
56	Latvia	0.34%	116	Tanzania	0.01%
57	Turkey	0.33%	117	Afghanistan	0.01%
58	Mongolia	0.29%	118	Malawi	0.01%
59	Uruguay	0.29%	119	Mali	0.01%
60	Ecuador	0.29%	120	Chad	0.01%

Source: Lall (1999)

4.3 Technological effort

Technological effort is essential to using technologies efficiently, even in ‘followers’ rather than ‘innovators’. In developing countries, much of such effort is informal – learning, incremental improvements, adaptations and copying – rather than formal research and development (R&D). Over time, however, R&D becomes more important. It is needed for countries to understand, absorb and adapt complex, fast-changing technologies. It is also useful in order to increase local content, move into more advanced functional areas and access technologies not easily available on licence. It is not possible to measure informal and formal technological effort. Available data provide only (imperfect) data on formal R&D across countries. However, even these show interesting and plausible patterns.

Table 9: Proportions of gross domestic expenditure on R&D (GERD) funded and performed by different actors in OECD, 1995

	North America	European Union	Nordic Countries
Proportion of GERD funded by the Business Enterprise sector (%)	59.3	52.5	58.7

[13] The figure of Singapore includes only university enrolments. If polytechnics are included, its ranking rises significantly and lies between Korea and Taiwan.

Proportion of GERD performed by the Business Enterprise sector (%)	70.8	62.1	66.5
Proportion of GERD performed by the Higher Education sector (%)	15.6	20.8	22.6
Proportion of GERD performed by the Government sector (%)	10.2	16.2	10.4
Source: Bell (2000), based on OECD data. Note: R&D by non-profit organisations is excluded			

The main actors in R&D activity are business enterprises. Table 9 shows their role in the OECD, where they accounted for around 50-60% of the expenditure on R&D in North America, the EU and the Nordic countries in 1995. They *performed* an even larger proportion of R&D – around 60-70%, since a significant part of the R&D funded by governments was carried out by business enterprises. The role of firms as the performers of R&D is even more striking (between 70 and 75%) in countries like Ireland, Korea, Sweden and Japan. If one focuses only on shares of industrial R&D, the share of business firms is even higher. Universities typically undertake around 15-20 per cent of national R&D, while government research institutions typically account for smaller proportions (around 10% in North America and the Nordic countries, and slightly over 15% in the EU). Again this would be much smaller if one focused on industrial R&D, excluding large public technology development effort in agriculture or health.

Table 10 shows R&D propensities across the main regions. Not surprisingly, it also shows great unevenness, even more than for skill formation (in statistical terms the two are highly correlated across countries, i.e. countries with high enrolments in tertiary technical subjects do more R&D). We focus on *productive enterprise financed R&D*, the measure most directly relevant to industrial technology[14]. As a percentage of GNP, this is nearly 400 times higher in the mature Asian Tigers than in Sub-Saharan Africa, and around 10 times higher than in the new NIEs and Latin America.

The regional averages conceal the large differences within regions. The leader in the developing world (again) is Korea, which runs neck-and-neck with Japan (and, surprisingly, leads all other OECD countries). Taiwan Province comes next, spending the same proportion as the UK, higher than the Netherlands or Italy. Singapore follows, with TNC affiliates conducing the bulk of industrial R&D. The three Tigers are in a different class from the rest of the developing world. Some successful exporters (like Mexico, Thailand, Philippines or Indonesia) depend heavily on TNCs to provide all innovative inputs and conduct very little local R&D – viable in the short-term but perhaps not in the long-term. Some, like India, have rising industrial R&D but their manufacturing lags technologically because of trade strategy or infrastructure problems. Most others, with small or weak industrial sectors, make little or no technological effort. They

[14] Total R&D in an economy would include defence, agricultural and other forms of R&D. In most developing countries, the great bulk of total R&D takes place in government laboratories and universities, generally isolated from the industrial sector. This is why we prefer the use of productive enterprise financed R&D.

Table 10: R&D Propensities and manpower in major country groups (simple averages, latest year available)									
Countries and regions (a)	Scientists/engineers in R&D		Total R&D	Sector of performance (%)		Source of Financing (% distribution)		Source of financing (% of GNP)	
	Per mill. Population	Numbers	(% of GNP)	Productive sector	Higher education	Productive enterprises	Government	Productive enterprises	Productive sector
Industrialised market economies (b)	1,102	2,704,205	1.94	53.7	22.9	53.5	38.0	1.037	1.043
Developing economies (c)	514	1,034,333	0.39	13.7	22.2	10.5	55.0	0.041	0.054
Sub-Saharan Africa (exc. S Africa)	83	3,193	0.28	0.0	38.7	0.6	60.9	0.002	0.000
North Africa	423	29,675	0.40	N/A	N/A	N/A	N/A	N/A	N/A
Latin America & Caribbean	339	107,508	0.45	18.2	23.4	9.0	78.0	0.041	0.082
Asia (excluding Japan)	783	893,957	0.72	32.1	25.8	33.9	57.9	0.244	0.231
NIEs (d)	2,121	189,212	1.50	50.1	36.6	51.2	45.8	0.768	0.751
New NIEs (e)	121	18,492	0.20	27.7	15.0	38.7	46.5	0.077	0.055
S Asia (f)	125	145,919	0.85	13.3	10.5	7.7	91.8	0.065	0.113
Middle East	296	50,528	0.47	9.7	45.9	11.0	51.0	0.051	0.045
China	350	422,700	0.50	31.9	13.7	N/A	N/A	N/A	0.160
European transition economies (g)	1,857	946,162	0.77	35.7	21.4	37.3	47.8	0.288	0.275
World (79-84 countries)	1,304	4,684,700	0.92	36.6	24.7	34.5	53.2	0.318	0.337

Source: Calculated by Lall from UNESCO and national data.

Notes: (a) Only including countries with data, and with over 1 million inhabitants in 1995.

(b) USA, Canada, West Europe, Japan, Australia and N Zealand. (c) Including Middle East oil states, Turkey, Israel, South Africa, and formerly socialist economies in Asia. (d) Hong Kong, Korea, Singapore, Taiwan Province. (e) Indonesia, Malaysia, Thailand, Philippines. (f) India, Pakistan, Bangladesh, Nepal (g) Including Russian Federation.

risk being caught in a vicious spiral of industrial backwardness, low skills, low FDI inflows and little ability to absorb or improve on modern technologies.

4.4 Foreign direct investment

Foreign direct investment – the main engine behind globalisation – is becoming critical to the transfer and development of new technologies, but its impact varies greatly according to the economic characteristics of the host economy. As with skill creation and technological effort, the benefits of TNC activity in the developing world are highly skewed – in fact, the ability of host economies to attract FDI and extract technological benefits depends largely on these two other activities. Box 2 describes the main features of current globalisation via FDI.

Box 2: Recent FDI – some important features

FDI flows are *growing faster than other economic aggregates* like national gross fixed capital formation (GFCF), world trade and GDP. *International production* (by TNCs and affiliates) is steadily increasing its share in global production.

TNCs dominate world *trade*: around two-thirds of visible trade is handled by TNCs, and the share is growing (UNCTAD, 1999). Their role is particularly large in products with significant economies of scale in production, marketing and innovation.

Of the visible trade handled by TNCs, around one-thirds is *within TNC systems*, between affiliates and parents or among affiliates. Such internalized trade contains the most dynamic form of exports today: *integrated international production systems*, where TNCs locate different functions or stages of production in different countries and link them tightly together. Affiliates participating in such systems tend to produce at massive scales (so realising enormous economies of scale) and use the latest technologies, skills and managerial techniques. Examples of complex integrated systems in which developing countries are important are automobiles (mainly in Mexico, Brazil and Argentina) and electronics (Malaysia, Singapore, Philippines and Mexico). The globalisation of the value chain is likely to spread across many other industries, and linking local production chains to them will become a major source of growth, technology transfer and skill development.

Some TNCs are locating *non-production functions* like accounting, engineering, R&D or marketing to affiliates – these are high value activities that can feed into manufacturing competitiveness and local capabilities (on the foreign share of R&D in developed countries, see OECD, 1999). This is what UNCTAD has termed the process of 'deep integration' of international production, as compared to earlier shallow integration where stand-alone affiliates would keep functions separate and relate to other affiliates or parents via trade. While the transfer of such functions lags that of production, particularly in developing countries, the long-term trend is clear. Data on patents taken out overseas (based on R&D conducted by affiliates) by OECD countries shows that some are very international in their innovative activity. Smaller countries are the most international for obvious reasons, but some large economies like the UK are also conducting very substantial amount of R&D overseas (Figure 6). However, for deep integration to occur, host countries have to be able to provide not just cheap labour but the whole array of modern skills, infrastructure, institutions, efficient business practices and supplier networks that TNCs need to be fully competitive in world markets. Very few developing countries are able to meet these needs.

Large companies with transnational operations increasingly dominate the process of *innovation*: the creation of new technologies and organizational methods that is at the core of competitiveness in all but the simplest activities. This goes with the trend to innovation in new information-based industries by smaller enterprises: in aggregate terms large TNCs account for larger shares of business-funded R&D spending in mature industrial countries. About 90 per cent of world R&D expenditure is in the OECD countries. Within this group, seven countries (led by the USA) account for 90 per cent of R&D, the USA alone for 40 per cent. In the US, just 50 firms (of a total of over 41 thousand) account for nearly half of industry funded R&D. In smaller industrialised countries, the level of concentration is much higher. In Switzerland just three firms account for over 80 percent of national R&D, in the Netherlands, four for nearly 70 percent. Access to new technologies thus involves access to the knowledge and skills of these leaders, which are increasingly unwilling to part with their most valuable technologies without a substantial equity stake. Thus, FDI becomes the most important – often the only – way of obtaining leading edge technologies.

TNCs are often central to the *exports by local firms* of technology-intensive products. Many of these products are difficult to sell in foreign markets because of the need for expensive branding, distribution and after-sales servicing. Thus, around 60-70 percent of consumer electronic products made by Tigers like Korea and Taiwan are sold to TNCs on an 'original equipment manufacture' (OEM) basis. The significance of OEM for Korea can be judged by the following statistics. In 1985, over 40% of Korean exports were in the form of OEM. In 1989, around 50-60% of VCR and TV, and about 80% of PC, exports by Korea were under OEM. In 1990, 70-80% of total Korean electronics exports was under OEM. TNCs are also active in *exports of low technology products* where factors like scale economies, branding, distribution and design are important.

TNCs can help *restructure and upgrade competitive capabilities* in import-substituting activities geared to the protected markets. Where the facilities are already foreign owned, TNCs are often better able to respond to liberalization than local firms by investing in new technologies and skills. They can also help local suppliers to upgrade, or attract investment by their suppliers overseas. This has been commonly found in Latin America. Where local firms own the facilities, TNCs help them to upgrade through M&As. While M&As by foreign firms are sometimes regarded with suspicion or resentment, they can salvage existing facilities that would not survive in a liberalised environment. In fact, with globalization and liberalization, international M&As now constitutes the bulk of FDI flows, accounting for over 80 percent of FDI in developed countries and around one-third in developing ones.

FDI in *services* is rising rapidly as traditionally homebound service providers (particularly in utilities) globalise their activities and take advantage of liberalization and privatization in their industries. The entry of service TNCs can provide rapid improvements in the productivity and efficiency to host economies, not only in their industries but also to their customers (many of which are important exporters).

TNCs transfer technologies to host countries in two ways: *internalised* (i.e. to affiliates under their ownership and control), and *externalised* (to other firms, by selling licences, equipment, management/consultancy services, subcontracting and so on). Taking both together, TNCs dominate the supply of new industrial technologies to developing countries. It is important, however, to distinguish between internalised and externalised modes of transfer for analytical and policy purposes.

The mode of technology transfer depends on several economic, strategic and policy factors. The nature and speed of change of technology, transfer costs and risks, corporate perceptions of benefits and risks, government policies, all play a role. Corporate strategies and host government policies aside, internalised transfers are preferred the more complex and fast moving the technology, the larger, more multinational and more specialized the supplier, and the less developed the capabilities of the buyer. Externalised ones are preferred the more stable and simple the technology, the smaller, less internationally experienced and more technologically diversified the sellers.

The profitability of a technology depends on its novelty, commercial value and complementarity to existing technologies, relationship to the firm's core business and pressure from imitators. TNCs do not generally sell their most profitable technologies as long as there are other means – FDI or exports – of exploiting them, though they use them increasingly in technology alliances when they expect greater technological rewards. They are willing to sell more mature technologies, as long as the buyer does not pose a competitive threat. Even where they perceive such a threat, they sell the technology while hemming in its use by restrictive clauses on exporting or further development. TNCs often manage externalised transfers to keep buyers from accessing the core elements of the technology. A competent technology buyer may therefore find that it becomes progressively more difficult and expensive – and finally impossible – to obtain new, commercially successful technologies at arm's length. A great deal of R&D goes into getting around this problem: all good follower strategies involve considerable technological effort to keep up with innovators.

The *content of technology transfer*, in either mode, differs by host country. It is commonly found that TNCs transfer different kinds and levels of technology to different affiliates in the same industry. The choice depends on two factors, corporate strategy and affiliate capabilities. *Corporate strategy* determines the role assigned to an affiliate in global division of production and other functions by the parent. It reflects the balance between location costs and risks, market size and growth expectations, and competitors' behaviour. The *technological capability* of the affiliate is probably more important. In making transfers, TNCs must choose between a range of technologies of different vintages and complexity (from simple assembly to full-blown R&D). The choice reflects the ability of an affiliate to deploy technology efficiently. This is why transfers to affiliates in developing countries with low skills and capabilities tend to have lower technology content than in advanced ones, and subsequent upgrading reflects the growth of skills and capabilities in the affiliate and the host economy. As with domestic capability building (with which technology transfer by TNCs is closely related), there are cumulative and self-reinforcing processes at work in technology upgrading via FDI.

This is important: it explains why globalization results in growing inequality in TNC technology transfers and export activity. Since each affiliate now has to compete in world markets rather than serve protected domestic markets, host countries with low capabilities and weak learning systems are left progressively behind those with dynamic capabilities. The relationship is not just one way, from capabilities to technology content. It is organic and interactive. The growth and depth of local capabilities depend critically on access to new technologies and on the learning required to master the technologies. Higher technological content poses greater challenges – and offers greater learning potential. The ideal virtuous circle is one where a host country raises its absorptive capacities and imports technologies to "stretch" its learning processes, the least desirable where initial capabilities are low and technology imports fail to stimulate further learning. The first leads to dynamic growth, the second to technological stagnation. Similar sequences apply to externalised technology transfers. However, here the buyer of the technology plays a larger role in deciding technology content. It is possible for a dynamic local firm, in a supportive learning environment, to push its technological frontier out quicker than an affiliate without conflicting with TNC global strategies. It is also possible, however, for a weak local firm to remain at the bottom of the technological learning ladder. This can be worse for the country than internalised transfer, since operational efficiency can be lower without the support of the foreign parent.

The two modes of technology transfer offer different costs and benefits (Box 3). However, the sheer pace of technical change and the spread of international production networks affects the choice that host countries make. The shift is clearly towards more internalised transfer: doing without FDI becomes a more risky, difficult and costly option. However, relying more on FDI does not mean a passive *laissez faire* attitude to TNCs. The international investment process suffers many market failures that call for remedial action, quite apart from domestic policies to boost receptive capabilities.

Box 3: Costs and benefits of internalised versus externalised technology transfer by TNCs

Advantages. Internalised transfer – through foreign controlled affiliates – provides other resources in addition to technology. As long as it does not crowd out local investments, it enables the host economy to expand its productive base and so use a larger range of technologies. Moreover, many technologies are only available in internalised forms, and their share in the total is rising. These are generally new, valuable technologies (based on expensive R&D or integral to branded products) that TNCs are unwilling to sell to unrelated parties. They may also be mature technologies used in processes integrated across several countries, as for assembly of semiconductors for export. For countries that need such technologies, or are part of export-oriented operations, there is no alternative to internalised transfer.

Even when technologies are available in externalised forms, internalised transfers are often cheaper and quicker. Where the technology involved is very large-scale, foreign investors are often able to mobilise the resources needed more efficiently than local firms. Where the buyer is likely to become a competitive threat, technology sellers charge high prices for new technologies, provide only older vintages or impose conditions to protect their markets. Such restrictive practices (e.g. export restrictions, prohibition of sub-licensing, ban on local improvements) have an economic rationale, but they raise the cost of externalised relative to internalised modes. Where technologies change rapidly, repeated contracting can be difficult, cumbersome and slow, leading to high costs or technological lags. Internalised modes ensure that affiliates have access to technologies as the parent generates them (though the technologies affiliates receive depend on their capabilities). In general, foreign affiliates tend to be in the forefront of introducing new management and organizational techniques, quality management standards, training methods and marketing methods. One of their most immediate responses to liberalization in host countries is to improve these aspects of affiliate operation and capabilities.

The most important benefit of internalisation, however, is that it provides access to the whole range of TNC technological, organizational and skill assets. Direct comparisons of costs of internal and external transfers tend to assume that affiliates and local firms deploy the technology with equal efficiency. This may be true of some developing countries, it is not of many others. Where the technology transferred is well in advance of local capabilities, the efficacy of the transfer depends on how local firms and affiliates cope with the learning process. Affiliates can have lower learning costs and periods because they draw upon the resources of their parents for the skills, information, experience and finance needed to absorb and adapt the technology. TNCs, in other words, may face lower market failures in technological learning in a new environment than local counterparts. They may charge affiliates for services provided but the marginal costs are likely to be low in relation to a local firm that has to create the skills, knowledge and structures from scratch.

Apart from technological learning, internalised transfers can provide other benefits. MNC marketing skills and brand names make it easier to commercialise new technologies within the host economy or overseas. If the transfer is part of an export-oriented operation, the affiliate gains access to regional or global markets, or to an integrated international network of parent company production (below). Internalised transfers can also lead to similar transfers by other MNCs in vertically linked activities. For instance, export-oriented MNCs in countries like Malaysia attracted their suppliers to invest locally and so deepen the production process.

Disadvantages. In internalised transfers, the host economy pays not just for the technology but for the whole package brought by the MNC, including its brand names, finance, skills and management. Where local firms possess the capability to use the technologies efficiently and do not need the other assets, internalisation can be more expensive than externalisation (assuming the technology is available at arm's length). The benefits of unpackaging FDI have been discussed for a long time, but they are not accessible to all host countries. Whether or not countries can unpackage FDI efficiently depends on the nature of the technology and domestic capabilities. For technologies readily available on license, and in countries with relatively developed entrepreneurial and technological capabilities, externalised modes are indeed likely to be cheaper. In other cases, they are likely to be more costly, inefficient or simply not feasible.

The most important drawback of internalisation lies in MNCs' ownership advantages: their efficient internal markets for skills and knowledge make it easy to use new technologies but can hold back deeper learning processes. There is likely to be less effort to absorb, adapt, improve and keep up with the technology in affiliates than in local companies buying the license or equipment. In the short term, an affiliate may be more efficient in *implementing* a given technology (i.e. it gets operational know-how more quickly). In the long term, however, it may develop fewer capabilities to adapt, improve and build upon the technology (know-why) than a local counterpart. In the restructuring process in response to liberalization, affiliates may neglect the development of R&D capabilities.

The countries that succeeded most in building up domestic technological capabilities, Korea and Taiwan, did so by restricting access to technologies via FDI. By encouraging externalised technology transfers and encouraging their local absorption in a strongly export-oriented setting, they forced local firms to develop and deepen their own technological capabilities. As these firms became internationally competitive and needed more sophisticated new products, they found that even externalised transfers were insufficient. The latest vintages of technology were simply not available from the innovators – they had to import technology by going into other arrangements (such as original equipment manufacture) and invest in their own R&D to imitate foreign technologies. Some firms became outward investors, to take over innovative firms or establish listening posts in industrial countries.

However, restricting inward FDI while encouraging local capabilities to absorb MNC technologies requires the rapid development of strong R&D capabilities in the host economy. In Korea, R&D capabilities were developed in the large *chaebol* fostered by the government; in Taiwan, largely populated by smaller firms, the government itself played a major role in R&D. Many countries are unable to mount such comprehensive and effective strategies. If they restrict FDI, they may end up with costly technological lags and inefficiencies.

FDI to the developing world has risen rapidly (Table 11) from an average of $29 billion in 1986-91 to $149 billion in 1997. However, these flows are very concentrated. South and East Asia and Latin America

Table 12: Leading 10 developing country recipients of FDI	
1986-91	1997
Singapore	China
China	Brazil
Mexico	Mexico
Hong Kong	Singapore
Malaysia	Argentina
Thailand	Chile
Brazil	Indonesia
Argentina	Venezuela
Taiwan Province	Malaysia
Korea, Rep. of	Thailand
Share 64.4%	Share 75.9%
Source: Calculated from UNCTAD (1998).	

together account for 93 per cent of total flows to developing countries (Table 3). The 43 least developed countries receive only half of one per cent in the period, and their share does not increase over time. In 1997, the bottom 50 recipients accounted for less than 1 per cent of FDI flows to the developing world.

Table 11: FDI Inflows, 1980-97

	Inflows by year ($ m)						Inflows (shares)	
	86-91 ave.	1990	1992	1994	1996	1997 (prov.)	1986-91	1997
World	159,331	183, 835	175,841	242,999	337,550	400,486	100.0%	100.0%
Developed countries	129,583	151,970	120,294	141,503	195,393	233,115	81.3%	58.2%
West Europe	66,470	98,941	85,837	78,417	99,954	114,857	41.7%	28.7%
North America	54,674	43,133	23,662	53,571	82,851	98,994	34.3%	24.7%
Other	8,439	9,896	10,796	9,515	12,588	19,263	5.3%	4.8%
Developing countries	29,090	31,766	51,108	95,582	129,813	148,944	18.3%	37.2%
North Africa	1,196	1,341	1,582	2,364	1,313	1,811	0.8%	0.5%
Sub-Saharan Africa	1,673	855	1,589	3,329	3,515	2,899	1.1%	0.7%
Latin America, Caribbean	9,460	10,055	17,611	28,687	43,755	56,138	5.9%	14.0%
Developing Europe	88	114	214	405	1,029	796	0.1%	0.2%
West Asia	1,329	1,004	1,827	1,518	303	1,886	0.8%	0.5%
Central Asia	4		142	896	2,084	2,627	0.0%	0.7%
South and East Asia	15,135	18,328	27,683	58,265	77,624	82,411	9.5%	20.6%
Central and Eastern Europe	658	300	4,439	5,914	12,344	18,424	0.4%	4.6%
Memo Item								
Least Developed (43)	781	603	1,463	844	1,965	1,813	0.5%	0.5%
Source: UNCTAD, *World Investment Report 1998*.								

At the country level, Table 12 shows that the top 10 developing host countries accounted for three-fourths of total FDI inflows in developing countries and that their share had risen over time. It is likely that 'high quality' FDI (export-oriented, using new technologies and creating local linkages) was even more concentrated; however, it not possible, from the available data, to demonstrate this statistically. Qualitative evidence nevertheless suggests that high quality FDI was largely limited to countries like Singapore, Malaysia, China and Mexico with export-oriented high-tech activities.

In sum, therefore, TNCs have much to offer in developing local capabilities. What technologies and functions they transfer to particular locations depends greatly on local capabilities. There is a role for policy in upgrading capabilities to optimise the transfer of MNC technology and in attracting higher quality FDI: providing better information to prospective investors and ensuring that their needs are met can be a vital tool of technology development.

The East Asian experience shows that both internalisation and externalisation strategies for technology transfer can be successful. The effects of these strategies on the development of domestic capabilities are different. The externalisation strategy, as in Korea and Taiwan, was to restrict the role of FDI, promote inflows in other forms, and support domestic enterprise in mastering increasingly complex activities (see Box 4 on Taiwan and Box 5 on Korea). This strategy is difficult and risky, and few other countries can replicate it even if the new rules of the game allowed it. It needs a strong base of technological skills, entrepreneurs able and willing to undertake risky technological effort and an incentive regime that shelters learning while imposing export discipline. It also needs a bureaucracy able to handle these tools efficiently and flexibly without being hijacked by particular interests.

Box 4: Promoting MNC technology spillovers in Taiwan

When the Singer Sewing Machine Company started operations in Taiwan in 1964, there were several small sewing machine manufacturers in the country, with poor technology and no standardisation, unable to compete in world markets. The government stipulated that Singer procure 83% of parts and components locally within 1 year, provide local suppliers with standardised blueprints, send technical experts to improve productivity, prepare materials specifications and inspect final products. Singer was to provide local sewing machine producers with its own locally made parts at no more than 15% above the price of parts imported from Singer's foreign parts. The company was also required to raise exports rapidly.

The company fulfilled all these requirements. It sent several technical and management experts to Taiwan to train and upgrade local suppliers and organise the entire production system. It provided a wide range of technical assistance to competing local sewing machine manufacturers free of charge. Suppliers received standardised blueprints, enabling them to work to common specifications, measuring instruments and access to Singer's tool room and technical advice. Classes were conducted for suppliers in technical and management problems.

The result of the local content policy was a significant transfer of technology, increased backward linkages and upgrading of competitive capabilities for the industry as a whole. Within three years Singer was using only local parts (except for some needles), and by 1986 was exporting 86% of its total output. Other local firms also became major exporters, as local parts were standardised and improved in quality. One reason for this success was that relatively little investment was entailed. The existing base of technological capabilities in the local suppliers made the transfer and upgrading of technology relatively rapid and low-cost. This pattern was repeated over time in several other industries.

These cases also illustrate that the less developed the country and the lower its domestic capabilities, the more it needs FDI to overcome obstacles to technological mastery in relatively complex activities. Government capabilities are crucial. Experience shows that pervasive selective interventions, if pursued inefficiently, impose high penalties on the economy. Import-substituting regimes that tried to build capabilities by encouraging industry behind high levels of protection, or favouring externalised over internalised modes, often ended up with a backward and inefficient technological base. Most made matters worse by neglecting the skill, financial, infrastructure and technical base firms need to develop capabilities.

Box 5: FDI and technology development strategies in Korea

The Korean government combined selective import-substitution with forceful export promotion, protecting and subsidising targeted industries that were to form its future export advantage. In order to enter heavy industry, promote local R&D capabilities and establish an international image for its exports, the government promoted the growth of giant local private firms, the *chaebol*, to spearhead its industrialization drive. Korean industry built up an impressive R&D capability by drawing extensively on foreign technology in forms that promoted local control. Thus, it was one of the largest importers of capital goods in the developing world, and encouraged its firms to obtain the latest equipment (except when it was promoting particular domestic products) and technology. It encouraged the hiring of foreign experts, and the flow (often informal) of engineers from Japan to help resolve technical problems.

The government permitted FDI only when other means of accessing technology were not available; it consistently sought to keep control firmly in local hands. Foreign majority ownership was not permitted unless it was a condition of having access to closely-held technologies, or to promote exports in internationally integrated activities. Some MNCs were induced to sell their equity to local partners once the technology transfer was complete. In the initial stages of development of important industries like electronics, however, MNCs played a major role in launching export-oriented assembly. Once it became clear that the pace of technological upgrading of foreign affiliates was slower than the government desired, the government pushed local firms to acquire independent capabilities. These capabilities ranged from the mastery and improvement of imported technologies to the absorption of foreign management practices and, later, to innovative R&D

The government also intervened in major technology contracts to strengthen domestic buyers. It sought to maximise the participation of local consultants in engineering contracts to develop basic process capabilities. The 1973 Engineering Service Promotion Law protected and strengthened domestic engineering services. The Law for the Development of Specially Designated Research Institutes provided legal, financial and tax incentives for private and public institutes in selected activities.

The government supported technological effort in several ways. Private R&D was directly promoted by incentives and other forms of assistance. *Incentive schemes* included tax exempt TDR (Technology Development Reserve) funds, tax credits for R&D expenditures as well as for upgrading human capital related to research and setting up industry research institutes. The government also gave accelerated depreciation for investments in R&D facilities and a tax exemption for 10 per cent of cost of relevant equipment. It reduced duties on imported research equipment, and a reduced excise tax for technology-intensive products. The Korea Technology Advancement Corporation helped firms to commercialise research results. A 6 per cent tax credit or special accelerated depreciation provided further incentives.

The government directly financed a large number of projects judged to be in the national strategic interest. There were three R&D programs supported by the government: the Designated R&D Program, the Industrial Technology Development Program and the Highly Advanced National Project Program. By 1993, the Government had invested around $3.5 billion in these programs.

The import of technology was promoted by tax incentives: transfer costs of patent rights and technology import fees were tax deductible; income from technology consulting was tax-exempt; and foreign engineers were exempt from income tax. In addition, the government gave *grants* and *long term low interest loans* to participants in "National Projects", which gave tax privileges and official funds to private and government R&D institutes to carry out these projects. The Korea Technology Development Corporation provided technology finance.

However, the main stimulus to the tremendous of industrial R&D was less the specific incentives to R&D than the overall incentive regime. This created the *chaebol*, gave them a protected market to master complex technologies, minimised reliance on FDI, and forced them into international markets where competition ensured that they would have to invest in their own research capabilities. This is why, for instance, why Korea has 35 times higher R&D by industry as a proportion of GDP than Mexico (with roughly the same size of manufacturing value added), which has remained highly dependent on technology imports. At the same time, it may not have created sufficient innovative capabilities on the part of the *chaebol*, which excel more at implementing rather than creating state-of-the-art technologies.

The other strategy, practised by Singapore, was to rely heavily on internalised technology transfers via FDI, but not to leave resource allocation and technology to free markets. This required the government to target complex technologies and induce MNCs to upgrade local functions (Box 6). This strategy also calls for a strong skill base and an administrative structure able to select technologies, target and bargain with MNCs and handle incentives efficiently.

Box 6: Singapore's FDI strategy

After a brief period of import substitution, Singapore switched to free trade. It pursued growth through aggressively seeking and targeting foreign direct investment, while raising domestic resource mobilization by various measures. Moreover, it chose to deepen its industrial and export structure, and used a number of selective interventions to move from labor-intensive to capital, skill and technology-intensive activities. Its technology acquisition policy was directed at consciously acquiring, and subsequently upgrading, the most modern technologies in highly internalized forms. This allowed it to specialize in particular stages of production within global systems of production, drawing on the flow of innovation generated by the firms and investing relatively little in its own innovative effort.

To attract foreign investment while inducing it to upgrade, Singapore developed a highly efficient system of attracting and targeting s. To support this targeting, it invested heavily in education, training and physical infrastructure. It developed an industrially targeted higher technical education structure, together with one of the best systems in the world for specialized worker training. Some of the leading training centres were set up jointly with s, one from India (the Tata group started the precision instruments training center).

Its FDI policies were based on liberal entry and ownership conditions, easy access to expatriate skills, and generous incentives for the activities that it was seeking to promote. It set up the Economic Development Board (EDB) in 1961 to co-ordinate policy, offer incentives to guide foreign investors into targeted activities, acquire and create industrial estates to attract multinational corporation, and generally to mastermind industrial policy. At times, it deliberately raised wages to accelerate technological upgrading, though in the mid-1980s a sharp rise in wages had to be modified to restore competitiveness. Over time, MNCs were drawn into the industrial policy making process, and the EDB emerged as one the world's most successful investment promotion agencies.

The public sector played an important role in launching and promoting activities chosen by the government, acting as a catalyst to private investment or entering areas that were too risky for the private sector. While the main thrust of Singapore's technology import policies was to target FDI, in recent years the government has also sought to increase linkages with local enterprises by promoting subcontracting and improving extension services. The government itself has launched R&D centres to create new capabilities in the economy, which would later attract participation. A good example is the Institute for Molecular and Cell Biology, established in the university and now securing research contracts from leading pharmaceutical s.

The decisions of MNCs about what new technologies to bring into Singapore were strongly influenced by the incentive system, the provision of excellent infrastructure, and the direction offered by the Singapore government. The government itself responded (or anticipated through proactive planning and consultation) by providing the necessary skilled manpower, often in consultation with s. In many instances, it was the speed, efficiency and flexibility of government response that gave Singapore the competitive edge compared with other competing host countries. In particular, the boom in investment in offshore production by MNCs in the electronics industry in the 1970s and the early 1980s created a major opportunity. The government seized it by ensuring that enabling support industry, transport and communication infrastructure, as well as skill development programs was available to attract these industries to Singapore. This concentration of resources helped Singapore to achieve significant agglomeration economies and hence establish strong first-mover advantages. It was able to attract related industries like the disk-drive industry, where all the major US disk-drive makers now have plants in Singapore. These industries demanded not only electronics components and PCB assembly support, but also various precision engineering-related supporting industries such as tool and die, plastic injection moulding, electroplating and others. The government actively promoted these supporting industries as part of a deliberate cluster promotion strategy.

As labour and land costs rose, the Singapore government used the opportunity to encourage MNCs to reconfigure their operations on a regional basis. A special program was launched to make Singapore attractive as a regional headquarters for s, and for regional marketing/distribution/service/R&D centres to support manufacturing and sales operation in the region. To promote such reconfiguration, new incentives such as the regional headquarters scheme, international procurement office scheme, international logistics center scheme, and the approved trader scheme were introduced.

4.5 Institution building

Technological capability building by enterprises needs institutional support. Many activities are difficult for firms to carry out on their own or in cooperation with each other. Private providers of services meet some needs – and this rises with the level of development – but there are limitations. There are often significant economies of scale involved. Many activities have a strong 'public good' element, making them unsuited to private provision. Each of the main factors of production thus has a need for public support through intermediaries: information, technology, skill formation, marketing and finance.

Take *technology support institutions*. These comprise the MSTQ system (metrology, standards, testing and quality), the R&D system (public R&D centres and universities), and the SME support system (extension services). Many developing countries have set up such support institutions copied from the developed countries (or set up during colonial times). Unfortunately, a large number of such institutions function poorly. They tend to be of poor quality, with inadequate equipment and poorly motivated and remunerated staff. Their services are often out of touch with the needs of the industrial sector and are offered passively. Their objectives – like creating new or appropriate technologies – can be unrealistic. The incentive and management systems within the institutions, often bureaucratic and sluggish, are not geared to providing services to firms. The 'culture' of R&D institutions and universities is very different from that of private firms. And so on.

Yet technology support institutions can provide vital knowledge, information and services to private firms, particularly when the firms themselves are technologically capable and aware.[15] All advanced countries are boosting their support systems. The Asian Tigers have invested heavily in setting up and improving such institutions. Even *laissez faire* Hong Kong provides subsidised technology support to its exporting firms, most of them small or medium sized (Box 7).

Box 7: Technology support in Hong Kong – the Hong Kong Productivity Council

HKPC was the first support institution of its kind in the region, started in 1967 to help the myriad small firms that constitute the bulk of industrial sector. Its focus has been to help firms upgrade from declining labour-intensive manufacturing to more advanced, high value added activities. It provides information on international standards and quality and gives training, consultancy and demonstration services on productivity and quality to small firms at subsidised rates, serving over 4,000 firms each year. Its on-line information retrieval system has access to over 600 international data bases on a comprehensive range of disciplines. Its technical library takes over 700 journals and has over 16 thousand reference books.

The HKPC acts as a major technology import, diffusion and development agent for all the main industrial sectors in the economy. It first identifies relevant new technologies in the international market, then builds up its own expertise in those technologies, and finally introduces them to local firms. Successful examples of this approach include surface mount technology and 3-D laser stereo-lithography. HKPC has also developed a number of CAD/CAM/CAE systems for the plastics and moulds industry, of which over 300 have been installed already. HKPC provides a range of management and technology related courses, reaching some 15 thousand participants per annum. For firms unable to release staff, it organises in-house training programmes tailored to individual needs. To help the dissemination of information technology, the council has formed strategic alliances with major computer vendors, and provides specially designed software for local industry, consultancy and project management in computerisation. HKPC provides consultancy services in ISO 9000 systems, and has helped several firms in Hong Kong to obtain certification. It assists local firms in automation by designing and developing special purpose equipment and advanced machines to improve process efficiency.

HKPC is a large organisation, with over 600 consultants and staff, a laboratory and a demonstration centre that can show the application of new technologies (in CAD/CAM, advanced manufacturing technology, surface mount technology, micro-processor technology, rapid prototyping and so on). In 1993-94, it undertook 1,354 consultancy and technology assistance projects, trained over 15 thousand people and undertook 2,400 cases of manufacturing support services. Because small firms experience difficulties in getting information on, and adopting, new technologies, and are exceptionally averse to the risk and cost involved, the HKPC has always had to subsidise the cost of its services. Despite the growth in the share of revenue-earning work and its withdrawal from activities in which private consultants have appeared, the government still contributes about half its budget. It is important to note that technological information market failures and the need for subsidised services occur even in a highly export-oriented economy, with highly developed financial services, like Hong Kong.

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[15] A World Bank study of technology support institutions in several countries concludes: "The surveys confirm an intensive use of outside support for technological improvement, and the range of these sources is varied. Users consider them complementary to other external, as well as internal, sources rather than as substitutes. If a firm has its own technical resources, personnel or an R&D department, it is far more likely to use outside technological resources, particularly public and private institutions. Larger firms are more likely to use TIs [technology institutions] than small firms. Over 80 percent of firms with an in-house laboratory and more than 350 employees use at least one public TI compared to 31 percent of firms with fewer than 50 employees that do not have an in-house R&D laboratory." See Goldman *et al.* (1997).

The Hong Kong government also supported local design capabilities by joining the private sector in starting a school of design. It financed the Hong Kong Design Innovation Company from the government because private sector design services were lacking and local firms were not aware of their value. Over the four years of its existence (mainly on government financing) this value has been recognised, but the HKDIC (now under the HKPC) is still not financially self supporting. Nevertheless, the growth of garment design capabilities in Hong Kong has helped its exporters to upgrade their products and start to establish their own brands in international markets.

The Taiwanese government also provides an extensive range of support to its myriad SMEs, allowing them to compete in extremely skill and technology intensive industries without being able to invest large amounts in in-house R&D. Box 8 describes some of its main initiatives.

Box 8: SME support in Taiwan

Taiwan's technology infrastructure for supporting its myriad SMEs is perhaps one of the best anywhere. There are around 700 thousand SMEs in Taiwan, accounting for 70% of employment, 55% of GNP and 62% of total manufactured exports. In 1981 the government set up the Medium and Small Business Administration to support SME development and co-ordinate the several agencies that provided financial, management, accounting, technological and marketing assistance to SMEs. Financial assistance was provided by the Taiwan Medium Business Bank, the Bank of Taiwan, the Small and Medium Business Credit Guarantee Fund, and the Small Business Integrated Assistance Centre. Management and technology assistance was provided by the China Productivity Centre, the Industrial Technology Research Institute (ITRI) and a number of industrial technology centres (for metal industry, textiles, biotechnology, food, and information). The government covered up to 50-70 per cent of consultation fees for management and technical consultancy services for SMEs. The Medium and Small Business Administration established a fund for SME promotion of NT$ 10 billion. The "Centre-Satellite Factory Promotion Programme" of the Ministry of Economic Affairs integrated smaller factories around a principal one, supported by vendor assistance and productivity raising efforts. By 1989 there were 60 networks with 1,186 satellite factories in operation, mainly in the electronics industry.

Several technology research institutes supported R&D in the private sector. The *China Textile Research Centre,* set up in 1959 to inspect exports, expanded to include training, quality systems, technology development and directly acquiring foreign technology. The *Metal Industries Development Centre* was set up in 1963 to work on practical development, testing and quality control work in metal-working industries. It later established a CAD/CAM centre to provide training and software to firms in this industry. The *Precision Instrument Development Centre* fabricated instruments and promoted the instrument manufacturing industry, and later moved into advanced areas like vacuum and electro-optics technology. The most important was perhaps the *Industrial Technology Research Institute* (ITRI).

ITRI conducted research and development for technology projects considered too risky. It had seven laboratories, dealing with chemicals, mechanical industries, electronics, energy and mining, materials research, measurement standards and electro-optics, but electronics was the institute's principal focus, with its Electronics Research & Service (ERSO) division accounting for two-thirds of the Institute's $450 million budget. ERSO has spun off laboratories as private companies including United Microelectronics Corporation (UMC) in 1979 and Taiwan Semiconductor Manufacturing Company (TSMC) in 1986, Taiwan's most successful integrated circuit makers. The Institute for the Information Industry was set up to complement ITRI by developing and introducing software technology.

Where the private sector was unable by itself to undertake complex or risky technologies, the government played a direct lead role. The government (led on the technical side by ERSO) entered into a joint venture with Philips to set up the Taiwan Semiconductor Manufacturing Company, the first wafer fabrication plant in the country. The government also strongly encouraged industry to contract research to universities, and half of the National Science Council's research grants (about $200 million per year) provided matching funds to industry for such contracts.

The Taiwan Handicraft Promotion Centre supported Taiwan's handicraft industries, particularly those with export potential. Its main clients were small entrepreneurs, most with under twenty employees. In addition, the Programme for the Promotion of Technology Transfer maintained close contact with foreign firms with leading-edge technologies in order to facilitate the transfer of those technologies to Taiwan.

The China Productivity Centre (CPC) promoted automation in industry to cope with rising wages and increasing needs for precision and quality. The CPC sent out teams of engineers to visit plants throughout the country and demonstrate the best means of automation and solve relevant technical problems, at the rate of approximately 500 visits making some 2000 suggestions per year. CPC also carried out more than 500 research projects on improving production efficiency and linked enterprises to research centres to solve more complex technical problems.

The government set up a science town in Hsinchu, with 13,000 researchers in two universities, six national laboratories (including ITRI) and a huge technology institute, as well as some 150 companies specialising in electronics. The science town makes special effort to attract start-ups and provides them with prefabricated factory space, five year tax holidays and generous grants. In the 1980s the government invested US$ 500 million in Hsinchu.

One striking example of government initiatives to promote technology development in smaller enterprises comes from Singapore. Box 9 describes this.

Box 9: Promoting high technology SMEs ('technopreneurs') in Singapore

Singapore is making strong efforts to promote technology based SMEs, termed 'technopreneurs'. It has mounted a series of focused strategies, in addition to those undertaken to promote SMEs generally.

Support services: Singapore is creating a conducive and stimulating business environment, through the provision of world-class facilities, for entrepreneurship to flourish. Innovative steps have been taken to improve information dissemination. To ensure that SMEs are not hampered by informational asymmetries, the government created a computer-based telephony system known as 'SME First Stop', which provides SMEs with information on business and operations. Besides disseminating information, SME First Stop also provides referral services that help SMEs obtain the exact assistance they need by referring them to relevant specialists and consultants. In 1998 alone, SME First Stop has dealt with more than 3,800 cases of assistance. Among these, financial and technical consultancy constitute the bulk (about 50%). Other forms of consultancy services are also available in areas of human resource management, productivity and quality indicators, as well as engineering and production management. For these consultancy services, SMEs apply for the Local Enterprise Technical Assistance Scheme, designed to help local SMEs defray up to 70% of the costs of modernizing and upgrading. These funds come from the government, which gives out S$20 million each year to about 1,500 SMEs.

Information portal: Another facility is the Technopreneurship Singapore portal, launched in February 2000 by the National Science and Technology Board. This portal serves as a platform for information exchange between technopreneurs and investors. On the one hand, technopreneurs can obtain information regarding, and even form networks with, business angels, venture capitalists, investment bankers, business consultants and other relevant agents. On the other hand, aspiring technopreneurs can also put up their business plans on the website where investors can easily access this information. The portal even goes as far as to provide a complete guide on the various support services available to high-tech startups. Sufficiently publicized, the Technopreneurship Singapore portal will go a long way in overcoming information deficiencies that tends to deter startups.

Physical infrastructure is also being developed and modified to facilitate technopreneurial activities. One example is the development of the Buena Vista Science Hub, which will serve as a focal point for science and technology related activities. Being in close proximity to local universities and research institutes, the Science Hub enjoys a locational advantage that will facilitate interaction and collaboration, as well as help generate innovative ideas.

Incentives: In November 1998, Jurong Town Corporation (a leading industrial property developer in Singapore) implemented the New Business Creation Incentive scheme which provided new startups with discounted rents for flatted factory space during their first three years of operation. A year later, it launched a pilot Technopreneur Centre within the Science Hub for the purpose of supplying technopreneurs with affordable facilities. These facilities are targeted at startups involved in high-tech areas such as microelectronics, non-hazardous chemical and life sciences technology, telecommunications, information technology, software development, and so on. The success of the above-mentioned schemes led to the Jurong Town Corporation to propose to expand the existing Technopreneur Centre, as well as duplicate similar centres in other parts of Singapore.

Incubators: The Technology Incubator Programme is another policy initiative to assist startups in bringing their ideas to successful commercialization. Launched in September 1998, the programme is essentially a mentor scheme in which Incubation

Management Companies, comprising three groups of experienced businessmen and technopreneurs, help nurture high-tech startups over a two-year "incubation" period. During this time, the management companies, which have vested interest in these startups, provide advice and guidance on business strategies and technological feasibility, as well as assistance in recruiting venture capitalists. The Management Companies, together with the National Science and Technology Board, will finance up to 85% of the business costs (subject to a maximum of S$600,000 over the incubation period) incurred by new startups. Response has been enthusiastic. As of August 1999, the three Management Companies have each received an average of 30 business proposals from startups in various fields of technology, including information technology, electronics, biotechnology, and so on. Of these, one has been approved and three have been given in-principle approval for support TIP. Considering that it has only been a year, this result is certainly encouraging.

Other sources of incubation support are also available. For instance, the Singapore Science Park Innovation Centre was specially set up to provide Singapore-registered technology startups with facilities ranging from office spaces and laboratories to legal services and seed finance. Opportunities for networking, collaboration and technology exchange are also provided by the Innovation Centre, giving technopreneurs the chance to benefit from synergies with other tenants at the Centre.

ICT industry: The government is also working hard to position Singapore as a hub for information and communications technology. One very recent scheme is the Java Tarik II, a joint initiative by Sun Microsystems Inc., Nanyang Technological University and the Infocommunication Development Authority of Singapore. This scheme has two objectives. One is to support and strengthen the ICT industry by nurturing local service providers, as well as managing branding and certification programmes. The other objective is to offer startup companies easy and affordable access to the latest technologies, networks and markets. By focusing on developing the local IT infrastructure, Java Tarik II complements its predecessor, Java Tarik I, which emphasizes building technology and product companies.

In terms of IT usage, Singapore has quite a good record. Today, one in three adults in Singapore has access to the Net. Singapore ranks second (after Hong Kong) amongst developing countries in terms of Internet usage, and tenth on the world list. The World Teleport Association has even awarded Singapore the "Intelligent City of the Year" award. Businesses are also increasingly encouraged to position themselves to be e-ready. Currently, the government awards grants to small businesses to induce them to engage in electronic commerce. To date, more than 300 grants amounting to S$4.5 million have been disbursed.

R&D capabilities: There are also plans to enhance the technology infrastructure by developing and nurturing research capabilities in local polytechnics, universities, research centres and government-funded institutes. Currently, NSTB supports 13 Research Institutes and Centres, which specialize in areas ranging from information technology to life sciences. Output from these been encouraging. To date, they have developed more than 500 new products and entered into 180 licensing agreements. The output of these research institutes will await commercialization by the industrial sector.

It is possible to reform public sector technology institutions and many developed and newly industrialising countries are doing just this. Box 10 describes the results of one such programme, funded by the World Bank in India.

Box 10: Linking Industry with Technology Institutions – The SPREAD Programme in India

In the late 1980s the World Bank launched an Industrial Technology Development project in India. One important component of this project was promoting industry-sponsored research at a number of public research institutes as well as the Indian Institutes of Technology, other universities and private research foundations. This component, the Sponsored R&D (SPREAD) Fund, was aimed at promoting research awareness especially among small and medium-sized companies and changing the 'research culture' of research laboratories and higher education establishments. The fund was administered by a newly established technology cell in the Industrial Credit and Investment Corporation of India (ICICI), a private sector development bank originally started by the World Bank. This technology cell helped firms to identify the appropriate research institute, develop their business plans, liase with the institute and generally 'hold hands' of new entrepreneurs (like a venture capitalist). The funds were given as conditional loans rather than grants, and the enterprise had to provide matching funds from its own resources.

By end 1997, around 100 firms had contracted 95 projects under this programme, with an average project size of $400 thousand and an average loan component of $170 thousand. So far, there have been no failures, though some 3-4 projects were likely to be cancelled. Most of the companies using the programme had never contracted research to a public research institute before; the large majority was small and medium sized. Some 50 different technology institutes were involved, including 5 Institutes of

Technology/Science, 12 universities, 5 private research foundations, and 28 government laboratories. Overall, the project is highly successful in technological terms; the subsidy element has been minimal and most firms claim that they will continue their links with the research institutions in the future.

A number of elements account for the success of this project. A private sector oriented 'matchmaking' intermediary (ICICI, a well-established private financial institution with intimate knowledge of industry) administered the funds and overcame information and trust barriers between researchers and business. A technically-oriented unit in this intermediary assessed the viability of applications and 'held hands' as the projects developed (more like venture capitalists than bankers). The finance was given in the form of loans rather than grants, with entrepreneurs making a substantial matching contribution. There was a significant effort to help technology institutions understand the needs of industry and change their operating 'culture'.

5. Towards a 'technology friendly' development policy

This section deals with some policy implications of the above discussion. It draws upon the experience of the Asian Tigers as well as some African countries, illustrating the two ends of the spectrum in technology capability building.

5.1 Technology strategy formulation

Let us start at the most general level: setting up broad technology strategy. Most developing country governments are not structured for designing and mounting effective industrial development strategy. The responsibilities and functions that affect competitiveness are scattered over an array of ministries and institutions: finance, trade, industry, labour, education, science and technology and others. These often have different objectives and do not communicate with each other on a regular and intimate basis. The first step in policy is therefore to set up an agency that can cut across competing interests and coordinate the ministries concerned.

Then comes the task of allocating resources, at various levels. At the highest level, it has to be decided which functional policies are assigned priority: education, infrastructure, finance, science and technology and so on. Even though the policies themselves may be mainly functional, the allocation of resources has to be selective, and so has to be based upon a strategic 'vision' in the government of what the main engines of future competitiveness are going to be. Most governments in the advanced and newly industrialising countries are now agreed that these lie in skill, technology and information based activities, though there are bound to be differences in terms of emphasis and specialisation. In less industrialised countries, the real issue is to build up competitive basic industries that create employment and use local resources — here the allocation has to reflect the most pressing needs of industrial restructuring.

At the sectoral and sub-sectoral levels, the government has to decide on which activities to support, not 'picking winners' in detail, but allowing winners to emerge in the sets of activities that hold most promise of long-term economic and technological growth (the 'drivers' of industrial competitiveness). These activities have to be identified for entire sets (clusters) of inter-linked activities that share strong technological externalities, and which use the existing base of skills and capabilities, can develop good backward linkages and face rising demand both locally and abroad.[16] The best way to find these 'drivers' is probably to examine closely the experience and strategies of countries that have similar endowments but have been successful in developing their competitive bases. As noted above, this is an art rather than a science.

The 'bottom line' in all strategies is, of course, how well they can be implemented in practice. While it is not difficult to establish a theoretical case for government policies to promote competitiveness and dynamic growth, and to show how other countries have done this successfully, each government differs in its own capabilities and the political economy within which it operates. It is therefore vital to bear in mind the risks of *government failure*. After all, the history of development policy is replete with cases of failed policies, and the current trend to liberalisation is partly a reflection of such failure.

In most less-industrialised countries there is no institutional mechanism for evaluating and setting science and technology priorities for the country. There is no developed science and technology plan, and the responsibility for relevant policies is spread over a large number of uncoordinated ministries and institutions. At most, technology planning is represented by a set of position papers put out by ministries or departments on their own, with no coordination or evaluation of national needs. This setting is not conducive to supporting technology upgrading.

In contrast, despite being strongly market and export-oriented, the Asian Tigers (excluding Hong Kong but including free trade Singapore) mounted elaborate strategies to identify and act upon strategic technologies (Dodgson, 2000). Many developed countries also have technology development strategies, though in countries like the USA and UK the process tends to be partly implicit (driven by defence and 'mission oriented' objectives); the EU has ambitious and well-funded programmes for technology promotion in the union. Interventionist governments like Japan and France also lay down explicit technology targets to promote national technological capabilities and selected industries or 'champions'.

In recent years, technological priorities in most developed economies are being set by '*Technology Foresight' Programmes*. These programmes are lengthy exercises by which all parties concerned with science and technology — industrial leaders and researchers, academia, services, financial institutions and the government — interact over a period to decide on technological trends and needs for their country. A

[16] Apparently 'sunset' activities like as labour-intensive consumer goods can still offer significant prospects for competitive growth if producers can shift into high quality segments — the Italian example in garments and footwear is a good example of how a country can retain a dominant position despite high wages. However, for developing countries this may prove even more difficult than diversifying into other activities, since all competitors are also trying to upgrade in activities with low entry barriers. Building specialised skills that give a strong competitive design or quality edge may prove extremely difficult – no developing country has managed to 'do an Italy' despite decades of clothing production.

number of developing countries, including India, Korea, Thailand and several Latin American countries, are conducting similar exercises.

The main advantage of Foresight Programmes over previous forms of technology priority setting is that the process itself creates awareness among all relevant parties of the state of technological activity in the country, emerging trends world-wide, and the implications for national competitiveness and priorities. It helps each to evaluate the strengths and weaknesses of the national innovation system and build consensus on what may be done. This makes it easier to mobilise resources and raise commitment. Science and technology resources in many countries are being allocated in accordance with foresight results. The UK provides a good recent example of a Technology Foresight exercise (Box 11), which was started in 1993 and completed in 1996. The allocation of UK science resources is now based on criteria yielded by the exercise.

Box 11: The UK technology foresight programme

Increasing competition and the rising pace of technological change have led policy makers in several industrialised countries to turn to innovation promotion as a tool of industrial policy. One means of promoting innovation has been 'technology foresight': this has been practised for a long time in Japan and France, but in the 1990s it has been taken up by traditionally non-interventionist governments like those in Germany, USA and UK. One reason is that firms can only keep up with technological progress by drawing on complementary sources of knowledge, thus requiring external support and co-ordination.

The UK technology foresight programme was announced in 1993, aimed at forging a closer partnership between scientists and industrialists and to guide publicly financed S&T activity. This programme was more market-oriented, less science-driven, than similar programmes elsewhere. There were three phases of the programme.

First, fifteen panels were established with experts in the whole range of markets and technologies of interest to the UK. A senior industrialist chaired each panel. The panels were charged with developing future scenarios for their areas, identifying key trends and suggesting means of devising and implementing appropriate responses. In 1995, each panel reported to a Steering Group, which synthesised the main findings and identified national priorities across all areas.

Second, the Steering Group's report distilled 360 recommendations to identify 27 topics under six themes:

- Social trends and impacts of new technologies
- Communications and computing
- Genes and new organisms, processes and products
- New materials, synthesis and processing
- Precision and control in management, automation, process engineering
- Environmental issues

Priorities were assigned to three categories of technology: *key technology* areas where further work was absolutely vital; *intermediate areas* where technological work needed to be strengthened; and *emerging areas* where work could be considered if market opportunities were promising and world class capabilities could be developed. The Steering Group also made recommendations on education and R&D infrastructure and the policy and regulatory framework.

Third, the implementation of the programme is now under way. Research Council programmes are being influenced by the report, and additional funding of £40 million has been announced for the Foresight Challenge Fund. This will be spent of projects assigned priority by the Group, with industry providing matching resources. The Panels are continuing to operate, now focusing on disseminate information to the SME sector and to business associations. More fundamentally, the Programme seeks to introduce a 'Foresight culture' into industry to induce firms to undertake more targeted research into areas of national technological importance.

Source: UK Government Foresight Website: http://www.foresight.gov.uk

In general, it is important for developing country governments to *review and improve their strategy making capabilities for technology development.* They should bear two principles in mind:

◊ *The strategy should provide a clear vision for technology development, and not focus on science promotion*. There is a common general tendency for 'Science and Technology Plans' to be formulated by scientists and researchers and to neglect pure science in preference to productive technology. The main failing tends to be to ignore the needs of industrial firms and the technological activity undertaken by them: these are the most important parameters for technology support.

◊ *The government should entrust one body with analysing technology needs and designing and implementing strategies*. This body should include high level representatives from all the ministries concerned as well as leading institutions (universities, research institutions, standards etc.) and the private sector. It should report to top levels of the government to ensure that crosscutting policies can be undertaken effectively. The strategy making body may consider undertaking a limited version of the Foresight programme to establish technology priorities and involve all stakeholders in the process.

5.2 Improving human capital and skills

A primary plank of technology strategy (in all countries and at all levels of income) is to improve the national stock of human capital. This partly involves putting more people through the education and training system, but it generally involves far more: improving the coverage, quality, relevance and responsiveness of the education provided. While skills have always mattered for development, the new competitive setting has raised their significance and changed their composition. A better quality workforce able to use new information-based technologies allows a country to respond flexibly to technological change, produce higher quality products, adopt and improve upon new processes and products and develop relevant (employable) skills as the job market changes. In particular, countries at all levels need larger stocks of technical and managerial personnel – but in developing countries the need is considerable greater. As we saw earlier, only a small handful of countries are investing enough in high level technical training to ensure that they keep abreast of such needs. Many others are not lagging, falling further and further behind the minimal needs of modern industrial competitiveness.

Despite these pressing human capital needs, many governments in developing countries seem to underestimate education and training or give them low priority. One reason may be that during macroeconomic adjustment and stabilisation (as in many countries over the past decade), ‘soft’ sectors like education and health tend to suffer. But there are other more serious reasons. Skill shortages may not appear as pressing constraints to growth. Enterprises can carry on with inadequate skills, obsolete technologies and low productivity (for a while at least, though they decline as the economy is liberalised). The lack of a skill base can deter high quality FDI entry or the upgrading of existing foreign operations, but again this may not be directly obvious. Traditional enterprises, particularly SMEs, may not even be aware of the nature and intensity of their skill shortages. There may be no culture of interaction between the productive sectors and education and training institutions. In such conditions, skill shortages may not felt, expressed or given high priority in the industrial sector.

However, it is clear that ignoring the pressing needs of skill upgrading is a grave mistake. The first step for policy makers is to establish the nature of skill provision and the needs, and the gaps between the two that need to be remedied, in each country. This requires conducting a ‘skills audit’ at the enterprise and industry level, accompanied by an assessment of the capabilities, staffing, curricula and facilities in teaching institutions. A good competitiveness strategy entails the continuous monitoring of skill gaps, with industry working closely with the educational establishment in establishing priorities and curricula. These can then yield programmes over the short, medium and long term for institutional and other upgrading.

In many countries of Sub-Saharan Africa, educational enrolments have declined from already low levels in recent years as a consequence of adjustment. Dropout and failure rates are high. The quality of training tends to be poor, often with outdated curricula unsuited to industrial needs. Though technical colleges exist, their equipment tends to be poor and staff weak. As a result, employers hold vocational and technical training in low regard, and employ few formally trained technical staff. By contrast, enrolments have been rising in the Asian NIEs, and governments have been attempting to improve quality and raise relevance to employers’ needs.

We must emphasise again the significance of education strategy for participating fruitfully in globalisation: attracting FDI and extracting its potential benefits require a strong base of human capital. In this regard, it is useful to consider how **Singapore** has used its skill creation system as a central tool of industrial and FDI policy (Box 12).

Box 12: Skill Development for Technology-Based Industrialisation in Singapore

The Singapore government has invested heavily in creating high-level skills to drive the targeted upgrading of the industrial structure. The university system was expanded and directed towards the needs of its industrial policy, its specialisation changed from social studies to technology and science. In the process, the government exercised tight control of curriculum content and quality, and ensured its relevance for the activities being promoted. Apart from formal education, the government also directed considerable effort to developing the industrial training system, now considered one of the best in the world for high technology production.

Singapore is a regional leader in employee training programmes held outside the firm. It set up the Skill Development Fund in 1979, along with a Skill Development Fund Levy, which collected a levy of 1 percent of payroll from employers to subsidise the training of low-paid workers. This marked the 'identification of a technology-intensive and knowledge-intensive industrial structure and high value-added orientation as national objectives [with] policy thinking focused on the importance of ensuring suitable human resources' (Inagami, 1998, p. 25). The SDF levy is disbursed to firms that send their low-paid employees to approved training courses.

Singapore has two national universities, four polytechnics and numerous public or non-profit specialised training institutes, creditable for an economy with less than 3 million people. Of its university graduates in 1996, 41 percent were in technical subjects. The polytechnics meet the needs for mid-level technical and managerial skills, again with a heavy emphasis on engineering. They cooperate closely with business in designing courses and providing practical training. Numerous Institutes of Technical Education provide blue-collar workers with secondary education with courses to upgrade skills; in 1996 they graduated nearly 6 thousand people in full time courses, another 17 thousand in part-time courses and 29 thousand in continuing education courses. An Adult Cooperative Training Scheme, introduced in 1993, provides training for semi- and unskilled workers aged 20 to 40.

The Vocational and Industrial Training Board (VITB) was established in 1979. It was an integrated training structure which has trained and certified over 112,000 individuals, about 9% of the existing workforce, since its inception in 1979. The VITB administers several programmes. The Full-Time Institutional Training Programme provides broad-based pre-employment skills training for school leavers. The Continuing Skills Training Programme comprises part-time skills courses and customised courses. Customised courses are also offered to workers based on requests from companies and are specifically tailored to their needs. Continuing Education provides part-time classes to help working adults. VITB's Training and Industry Programme offers apprenticeships to school leavers and ex-national servicemen to undergo technical skills training while earning a wage. On-the-job training is carried out at the workplace where apprentices, working under the supervision of experienced and qualified personnel, acquire skills needed for the job. Off-the-job training includes theoretical lessons conducted at VITB training institutes or industry/company training centres. Unusually, the government has collaborated with foreign enterprises (Japanese, French, Indian, German and Dutch) to set up these centres, funding a large part of employee salaries while they are being trained in state of the art manufacturing technologies. Later the Singapore government also worked jointly with foreign governments (Japan, Germany and France) to provide technical training.

Under the Industry-Based Training Programme, employers conduct skills training courses matched to their specific needs with VITB assistance. VITB provides testing and certification of its trainees and apprentices as well as trade tests for public candidates. The Board, in collaboration with industry, certifies service skills in retailing, health care and travel services. Using various grant schemes, the Skills Development Fund provided one training place per four employees in 1992; by 1995, this had risen to one training place per three employees. The salary ceiling for the SDF levy was raised in 1995 (from S$750 to 1,500) to widen its coverage and raise the amounts collected to fund training. National investment in training in Singapore reached *3.6 percent of annual payroll* in 1995, and the SDF plans to raise it to 4 percent by 1999. This can be compared to an average of 1.8 percent in the UK in 1998.

The initial impact of the programme was found mostly in large firms. However, efforts to make small firms aware of the training courses and provide support for industry associations has increased SDF's impact on smaller organisations. SDF is responsible for various financial assistance schemes to help SMEs finance their training needs and to upgrade their operations. It has also introduced a Development Consultancy Scheme to provide grants to SMEs for short-term consultancy for management, technical know-how, business development and manpower training.

The Training Voucher Scheme supports employers to pay training fees. This Scheme enabled the SDF to reach more than 3,000 new companies in 1990, many of which had 50 or fewer employees. The Training Leave Scheme encourages companies to send their employees for training during office hours. It provides 100% funding of the training costs for approved programmes, up to a maximum of $20 per participant hour. In 1990, over 5,000 workers benefited from this Scheme. The success of the Skills Development Fund is due in part to an strategy of incremental implementation. Initially, efforts focused on creating awareness among employers, with *ad hoc* reimbursement of courses. The policy was then refined to target in-plant training, and reimbursement increased to 90% of costs as an additional incentive. Further modifications were made to encourage the development of corporate training programmes by paying grants in advance of expenses, thus reducing interest costs to firms.

The Economic Development Board assesses emerging skill needs continuously in consultation with leading enterprises in the economy, and mounts specialised courses. For instance, in 1998, it offered courses on wafer fabrication, process operation and control, precision engineering, high-end digital media production, and computer networking. The EDB also started an International Manpower Programme in 1991 to help companies based in Singapore to attract skilled personnel from around the world. In 1997, around 2500 professionals and 10,400 skilled workers and technicians were recruited with EDB assistance.

There has been a significant shift in the workforce to more highly skilled jobs. The proportion of professional and technical workers has risen from 15.7 percent in 1990 to 23.1 percent in 1995. Despite these efforts, "there is a chronic shortage of skills of all sorts in Singapore … The MTI [Ministry of Trade and Industry] has projected that given current growth rates, Singapore will be short of some 7,000 graduates annually by the year 2000." (Low, 1998, p. 26)

Singapore's case is very similar to that of **Ireland**, a fast growing economy that has overcome centuries of industrial backwardness and marginalisation to become a high-tech centre in Europe.[17] This has been accompanied by significant technology upgrading and deepening. In 1977, R&D only 0.77 per cent of GDP, of which only one third of R&D was performed by business enterprises. The other two-thirds was undertaken in public institutions – nearly 50 percent in government organisations and about 15 per cent in universities. By 1997, the R&D/GDP ratio was almost twice as large, with almost 70 per cent performed by business enterprises. The share of higher education institutions increased a little to nearly 20 per cent, while that of government organisations dwindled to 7 per cent.

As in Singapore, Ireland's technological transition was driven by inward FDI. In the early 1980s, foreign affiliates accounted for nearly two-thirds of manufacturing R&D (which accounted for almost all business enterprise R&D). By the early 1990s they accounted for a slightly larger proportion of much larger manufacturing R&D (which still accounts for nearly 90 per cent of business enterprise R&D). This massive increase was made possible by a rapid rise in *education and skills*. Ireland expanded its higher education system from the 1960s, with a strong focus on first degrees. Postgraduate training had little priority in Ireland before the late 1990s. Regional Technical Colleges were established in several cities in the late 1960s to supply crucial craft and technician level skills for technology and business. Unlike universities, which had a strong liberal arts tradition apart from science and technology, Technical Colleges did not provide arts and humanities training, focusing on 'economically useful' skills. Two were later up-rated to universities as the demand for graduate skills grew (Limerick and Dublin City Universities).

Soon after the electronics industry was launched, a National Microelectronics Research Centre was established at University College, Cork. Leaning heavily on EU funding – as did most technical research in Ireland at the time – NMRC grew tenfold from its original staff of 20 and now provides a useful part of the R&D and training infrastructure serving multinational and (increasingly) indigenous electronics companies. While it does not transfer inventions to industry for commercialisation, it does now do basic research for industry (e.g. for Intel). During the 1980s, EU funding for university and company research grew dramatically as the EU set up Framework Programmes. This provided incentives for reorientation of university efforts towards industrially relevant issues.

Formal education and training are only part of the skill creation system. An equally important part is played by *post-employment skill acquisition*, both on the job and by formal training. Training in enterprises can be a very effective and economical way to develop the skills of the workforce,[18] particularly where employers are well-informed about skill needs. Some may also have the expertise and resources to provide training in traditional and emerging skills. Their costs tend to be low as compared to pre-employment post-school training, though they lose part of the benefits of training is their employees leave. Studies suggest that enterprise-based training yield higher private returns than other post-school training modes, both in developing and industrialised countries. In these other modes, there are significant risks of providing inappropriate or unnecessary skills. Thus, the *prima facie* case for the cost-effectiveness of enterprise-based training is strong.

Table 13: Training in Developing Countries and Productivity Gains

Country	Productivity Gains
Indonesia (1992)	71.1
Colombia (1992)	26.6
Malaysia (1994)	28.2
Mexico (1992)	44.4

Source: Tan and Batra (1992)

In addition to cost-effectiveness, enterprise training is an essential complement to new investment in technology, plant and equipment as well as new organisational methods. Many studies in mature industrial countries suggest that the shortage of appropriate worker skills is a major constraint on the adoption of new technologies, while well-trained workers accelerate adoption.[19] Country studies in developing countries (Tan and Batra, 1995) demonstrate that training raises productivity (Table 13). However, many employers, particularly SMEs, do not realise benefits of training or exaggerate its costs.

In Malaysia, these productivity effects were higher when firm training was accompanied by complementary investments in new technology (Box 13). Workers also benefited from firm investments in training and technology.

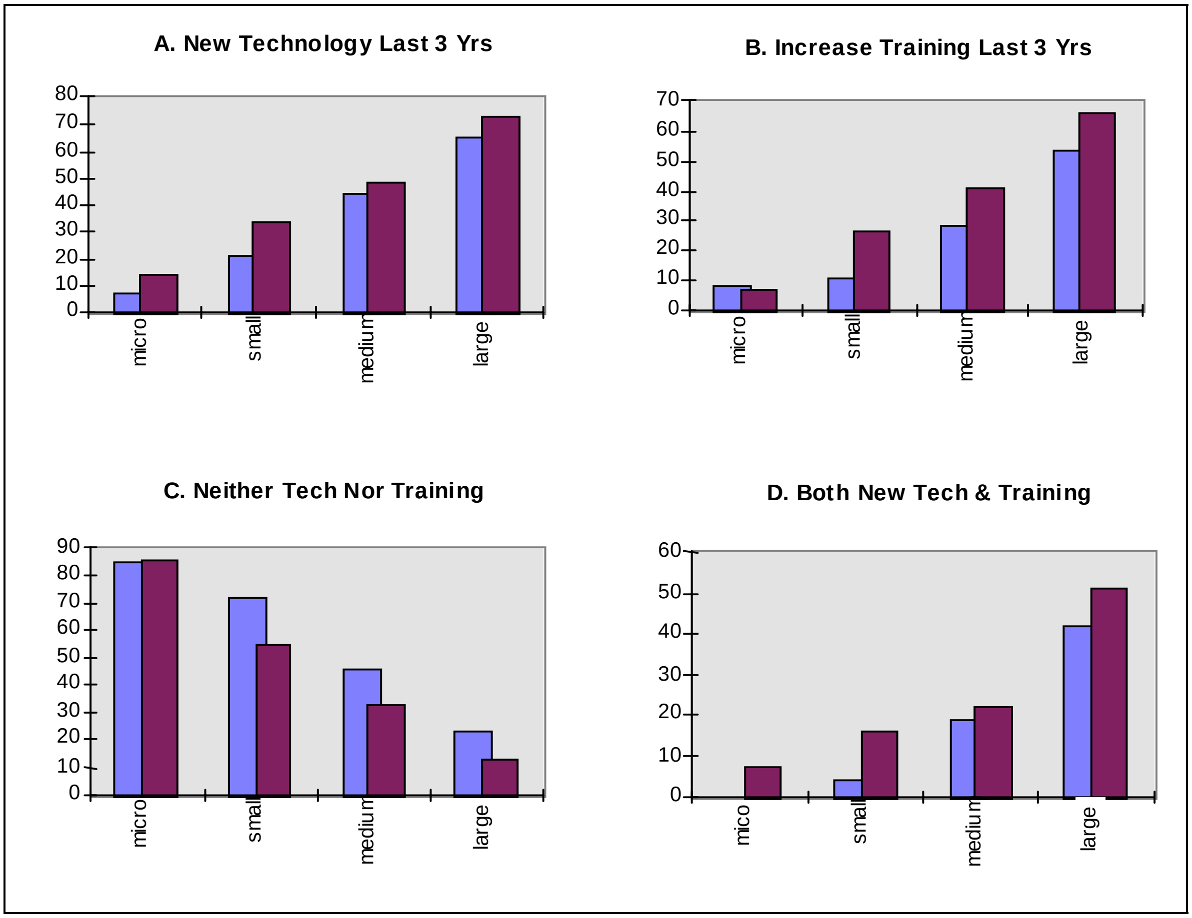
Box 13: Efficiency, Technology and Training in Malaysia

In a study of Malaysian enterprises, current efficiency levels of firms were linked to past investments in technology and training. The figure below shows the percentage of efficient and inefficient firms that: introduced new technology (including computerisation, automation and new production machinery) in the past 3 years; increased provision of training over the last three years; neither invested in new technology nor increased training; and both introduced new technology and increased training.

Panels A and B reveal a strong relationship between size and the introduction of new technology or increased training provision over the past three years. Within each size category, efficient firms were more likely to have done so than inefficient firms. Panels C and D, which combine responses from both questions, are mirror images of each other. Firms that neither invested in new technology nor increased training are primarily micro and small firms, while those that did both are found mainly among larger

[17] This description of Ireland is taken from Bell (2000).
[18] This draws extensively on the work done by Tan and Batra (1995).
[19] On the USA see Bartel and Lichtenberg (1987), and on the UK various papers in Booth and Snower (1996).

firms. In each size category, efficient firms were less likely to have done neither, and more likely to have done both, as compared to inefficient firms. These trends reinforce the links between new technology introduction, rising skill requirements, increased training, and higher productivity.



Source: Tan and Batra (1995).

Not all employers provide training, however, despite demonstrated gains in productivity. As noted, some are unaware of the benefits or methods of training, while others fear the loss of trained workers to other firms. Training is a form of investment in employees' human capital – and it involves costs: in materials, time and foregone production. Thus, the incidence of training is highly variable (Table 14).

Table 14: Incidence of Enterprise Training in Some Developing Countries

Country	Sample Size	% firms providing informal training	% firms providing any formal training	% firms providing internal formal training	% firms providing formal training externally
Colombia (1992)	500	75.9	49.6	3.7	48.7
Indonesia (1992)	300	18.5	18.9	9.7	14.2
Malaysia (1994)	2,200	83.1	34.7	25.2	20.4
Mexico (1994)	5,072	11.3	10.8	5.8	7.9
Taiwan (1986)	56,047	N/A	9.3	-	-

Source: Tan and Batra (1995)

Recent surveys provide insights into the incidence of training in manufacturing firms in Mexico, Colombia, Indonesia, Malaysia and Taiwan. These estimates illustrate broad patterns of training in the manufacturing sectors of the different countries. The table suggests that a sizeable proportion of enterprises in all five developing economies provide no worker training at all, either informal on-the-job or structured formal training. This problem is especially pronounced in small and medium enterprises, where more than half the firms give no formal structured training, and over a third do not provide any informal training. Several constraints on training – such as poor information about the benefits of training, high training costs, inability to exploit scale economies in training, weak management, absence of competitive pressures or market imperfections – are clearly at work. The market failures in skill creation are laid out in Box 14 (Lall, 1999).

Box 14: Market failures in education and training

The failures for each of the three components of the system are as follows. For *the trainee*:

◊ Externalities: The failure to recoup all the benefits of educational investments. Some benefits of skill creation inevitably accrue to others, since skills are not used in isolation.

◊ Information gaps and uncertainty: Individuals may not know of the future value of investments in education and training or of particular skills, and they may not know what skills are needed in the future.

◊ Risk aversion: Even if individuals can forecast the probability of getting returns on skill investments, they may prefer more certain short term returns to available jobs.

◊ Lack of certification of skills acquired during enterprise training: This makes the investment in such training less attractive, since its value to other firms is reduced.

◊ Capital market deficiencies: Individuals may not be able to finance their learning costs and foregone earnings, because capital markets lack the information and monitoring capacity.

For the *education and training system* (public and private):

◊ Lack of information on educational needs in industry and demands from students

◊ Capital market deficiencies in raising the funding for better standards

◊ Uncertainties about future skill trends, greater in a period of rapid technical change and overwhelming in a situation where skill needs are determined by industrial policy.

◊ High costs of educational services provided.

◊ In the public training institutions, bureaucratic and rigid management, poor remuneration and inadequate incentives for trainers, lack of interaction with the market, and low standards. This can lead to obsolete and irrelevant curricula, poor teaching and equipment, and over-emphasis on abstract rather than practical training.

◊ In the private sector system, risks of variable and unsatisfactory standards in the absence of effective monitoring.

For *enterprises* providing training to their employees:

◊ Low absorptive capacity on the part of poorly educated workers.

◊ Low educational qualifications on the part of employers and managers.

◊ Lack of appreciation of or information on the benefits of training, and lack of knowledge of 'best practice' technology and skills in relevant activities.

◊ Lack of training materials or teachers in-house.

◊ Inability to form efficient training programmes in line with changing skill and technology needs.

◊ Lack of specialised institutions to provide appropriate training at reasonable cost, or lack of necessary interactions between these institutions and enterprises.

◊ Lack of finance to cover costs of training.

◊ Lack of full appropriability, as trainees leave for better jobs after training. This creates a bias toward training in specific skills that do not have value to other firms, but this is rarely possible.

◊ Lack of technological dynamism, with enterprises content to stay with existing technologies, equipment and skill levels. This is exacerbated by policy regimes that stifle competition or hold back exposure to world markets.

A comprehensive strategy for skill creation has to address the whole range of market failures by a mixture of institutional and other policies. While we cannot consider these here, some general **policy recommendations** on skill upgrading in developing countries are as follows:

- Conduct a *comprehensive survey (or audit) of skill needs*, not just at present but in the future in a more complex and competitive industrial structure, and continue them on a regular basis.[20] International benchmarking must, in addition, be used to assess skill needs. This can serve as the basis for prioritising training needs at all levels; the government should *target new skills* that are likely to be critical for future competitiveness, in particular in food-processing, capital-intensive process industries, and electrical and electronics engineering. There is also a need to evaluate the skill needs of supporting service activities, e.g. information technology, finance and marketing.

- Ensure *effective interaction between employers and training institutions*. There is a case for setting up a coordination unit to sponsor and implement interaction on a continuous basis, with majority representation by the private sector and resources to ensure that industry needs are addressed.

- Launch new types of *training institutions more directly linked with, and in some cases managed by, industry*. This requires the training of middle management, production management and design skills. Other industries also need such centres. Industry associations have been rather inactive in promoting training services for their members, and the government should provide incentives or seed money for them to launch centres on their own. In East Asia, many valuable training and technical services were

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[20] For instance, the UK Government conducts Skills Audits to compare the skill levels of young people in the UK against benchmarks such as France, Germany, the USA and Singapore.

provided by industry associations, which grew from being pressure groups to gain government favours into more progressive service organisations.

- *Encourage firm-level training* by information and persuasion and, where desirable, by incentives and the setting up of institutions and programmes. A scheme worth considering is giving generous tax allowances to smaller firms for investing in training (Malaysia and Thailand give 200% tax deduction). Provide better *information* on and *monitoring* of private sector training. At present there is little information available on this and no systematic measures to promote or improve it.
- *Target SMEs* by special information and incentive programmes to recruit better-trained labour and to invest in formal training. Their method of skill transmission tends to be confined to apprenticeship systems, where craftsmen teach young workers, largely with little formal education, traditional methods that have been used over time without much change. The government should assist by providing substantial subsidies to SMEs to invest in training and by setting up activity specific training centres.

Finally, note that a fully liberal policy regime may not be the best setting in developing countries for skill development when there are heavy, prolonged and unpredictable costs in mastering difficult technologies. Such costs deter entry into complex activities or more demanding technical functions. They are generally greater when new skills are needed, technologies need considerable effort and information to absorb, there are extensive spillovers, and domestic (rather than foreign) firms are involved. In these conditions, capability development requires policy intervention: there is a case for “infant industry” protection of skill and technology development. Such promotion can take many forms and encompass many markets (Lall, 1996, Stiglitz, 1996). Once governments set about changing the technological structure of industry, they create the need for new skills that only they can foresee. They have to ensure, in other words, that the education and training system is co-ordinated with the industrial system as both evolve: this coordination becomes an integral part of industrial and education policy. This is just what the mature Asian Tigers did (Ashton *et al.* 1999).

5.3 Stimulating and improving technology imports

Another basic prerequisite for technology development policy is access to international technology and information. Information can flow into an economy in many forms: books, broadcasting, telecommunications, journals and conferences; migration of skilled people; imitation and ‘reverse engineering’; licensing or other contracts; capital goods (separately or as a turnkey factory); direct investment, consultants, management contracts; or buyer-seller relations in product export markets. Access to information is useful in all forms, and it is vital for developing countries to open and exploit as many channels as possible. This means that the information infrastructure must be able to provide efficient access to all potential users. It also means that the right choices must be made between different forms of information to maximise the benefits for domestic learning, in particular when technology development (rather than pure knowledge) is concerned.

Each form of technology transfer requires different local absorptive capabilities and has different effects on learning. In general, the more 'packaged' and simpler the imported information (say, a low-technology activity with foreign equipment, inputs, technical and managerial know-how, finance and marketing), the easier it is to transplant to a new setting: using it effectively only requires training local employees in the necessary operational procedures. The archetypal example is a foreign-owned garment assembly operation in an export-processing zone, with low value added and no domestic supply linkages, a few weeks of training sufficing to bring it to internationally competitive standards. There is little local skill needed and little new learning generated.

Contrast this with the import of a complex new engineering technology in an unpackaged form, with capital goods and licenses selected by the developing country enterprise, put together by local engineers and managers and supported by high levels of local content. This requires a high initial base of capabilities, entails a lot of technological and skill creation effort, and generates considerable new learning. At every level, technology imports and local technological effort can complement each other or be substitutes. The most efficient learning strategy is to use foreign knowledge to feed into local effort; however, because of the risks and lack of appreciation of the benefits of such effort it is common to find foreign knowledge simply substituting for domestic learning. This leaves the country permanently dependent on foreign technology, beyond levels that are efficient or desirable for long-term development.

This is not to suggest that easy packaged technologies are not beneficial. On the contrary, this is what most developing countries need to start their industrialization process and launch export-oriented manufacturing. However, it *is* only a start: they have to move up the knowledge-intensity of production as wages rise and new competitors appear. The appropriate mix of foreign and indigenous knowledge is that which utilises existing domestic capabilities to the maximum while extending and deepening them to handle more advanced knowledge. Relying on packaged imported knowledge is unlikely, by itself, to achieve the latter: it creates some skills, but largely limited to the use of simple technologies. To move on to the next level of knowledge complexity requires boosting local sources of skills and knowledge. The example of *Taiwan (China)* shows how foreign and domestic knowledge can be combined successfully by the government to catalyse learning (Box 15).

Box 15: Taiwan (China) technology development through alliance formation

When IBM unveiled its first PC based on the PowerPC microprocessor in New York in June, 1995, it was followed one day later by the unveiling in Taipei of PowerPC based products by a group of 30 firms from Taiwan (China). Taiwan was the first country outside the US to have developed a range of state-of-art products based on the new technology. The Taiwanese firms had not done this on their own. They were part of an innovation alliance, the Taiwan New PC Consortium formed by a government research institution, the Computing and Communications Laboratory (CCL). The Consortium was set up in 1993 to bring together firms from all parts of the information technology industry in Taiwan with the specific purpose of transferring, mastering and diffusing the new PowerPC technology. It covered the whole range of products from PCs and peripherals to software and multimedia applications, as well as semiconductor manufacturers that would make their own versions of the new chip. The firms involved were relatively small by international standards, and CCL brought them together and negotiated on their behalf with IBM and Motorola.

This was not the only instance of strategic alliance formation by the government in Taiwan (China) to stimulate innovation and take industry to technological frontiers. The Industrial Technology Research Institute (ITRI) had led in the formation of some 30 consortia in the IT industry over the 1990s. This had focused on products like laptop computers, high-definition television, videophone, laserfax, broadband communications, digital switching devices, smart cards and so on, helping firms to move up the 'technology chain'. In each case, ITRI had identified the products, tapped channels of technology transfer, mobilising the firms, handling the complex negotiations with developed country firms, and covering intellectual property issues. The individual firms developed their own versions of the jointly developed core products and competed in final markets at home and abroad. Their size limited their ability to have done this on their own.

One important and well-known case of government-led technology development in Taiwan is that of semiconductors (Mathews and Cho, 2000, Mathews and Poon, 1995). By the 1970s, Taiwanese industry was falling behind technologically in an industry that provided crucial inputs into its burgeoning electronics export sector. The lag arose mainly because local firms were too small to set up the capital-intensive facilities involved and to invest in developing the necessary skills. In 1976, the Electronic Research and Service Organization (ERSO), part of the Industrial Technology Research Institute, imported and started to develop process technologies for very large integrated circuits (VLSI). By mastering this technology and creating a base of technical skills, ITRI was able to spin off the first integrated circuit manufacturer in Taiwan in 1982. This firm (UMC) was able to conclude agreements with three Chinese owned start-ups in Silicon Valley in the US to develop advanced chip designs. This was successful, and UMC went public in 1985. In 1987, using VLSI technology from UMC, the government set up a joint venture (the Taiwan Semiconductor Manufacturing Company, TSMC) with Philips of the Netherlands and local private interests for wafer fabrication.

TSMC grew rapidly and supported the development of design and manufacturing capabilities in many small electronics firms. This further encouraged the entry of private companies into semiconductors, microprocessors and related electronics products. TSMC is today the world's largest dedicated chip manufacturing foundry, holding a 24% global market share, followed by UMC with 20%. These foundries are increasingly used, not just by local chip design houses without in-house manufacturing capabilities, but also by US giants like Intel and Motorola, which prefer to outsource chips because of business cycles and the rising cost of new wafer fabrication plants.

By contrast, consider the case of *Kenya*. Despite years of liberalization, Kenyan industry imports surprisingly little new technology, showing how poorly it is coping with the new environment. There are no longer any obvious policy impediments to technology import. The intellectual property regime is improving though implementation is slow and cumbersome. However, this does not seem to be a significant constraint to the transfer of technology: the Kenyan market is too small and local competition too under-developed for weak IPR implementation to hold TNCs back from transferring technology. There are no controls on capital goods imports or licensing. Tariffs on machinery are uniformly low, around 5-10%. Earlier controls on foreign exchange remittances are virtually gone. Unlike many import-substituting countries, Kenya never had legislation for regulating the transfer of technology (apart from a 3-5% limit on royalties, which is now gone). The government did not intervene in contract negotiations between domestic and foreign companies. The policy regime does not therefore constitute a constraint to manufacturing enterprises seeking to upgrade technology.

One reason for the tepid technological response of the Kenyan industrial sector may be the uncertainty and lack of credibility of the liberalization process. However, this is not sufficient: it has diminished over time as it has become more widely accepted by industry that liberalization is irreversible and will only accelerate. The real reason lies in *structural problems* of technology upgrading: lack of information on sources of technology, cost of upgrading technology (reflecting the distance between existing technologies and the frontier), lack of managerial and technical skills and financial constraints.

Many of these can be reduced by technology support and skill formation policies. In particular, a strong campaign to persuade firms of the importance of investing in technological activity and training, backed by efforts to ‘plug’ each of the gaps mentioned, appears to be needed. A few Kenyan firms *are* paying attention to technology upgrading. While they are not technologically advanced or innovative by NIE standards, they are doing a creditable job in the new liberal environment. Box 16 illustrates with the example of one such firm.

Box 16: Technological Upgrading by Power Technics, Kenya

Power Technics started in 1982 as an electrical engineering firm. It manufactures lighting equipment and fixtures under licence from Groupe Schneider (France) and Thorn Electrical (UK); and it provides electrical cabling lighting systems for buildings. Its total employment of 180 people includes 14 engineers – these have been extensively trained in-house to overcome the poor quality of training given in universities. It has developed considerable expertise in sheet metal work, for which it uses computer numerically controlled (CNC) machine tools, one of the few firms in the region to do so. Its own engineers are able to maintain the CNC tools after relative brief (10 days each for two engineers) training with the suppliers in Europe. The firm imported powder-coating technology from India; having mastered this technology, it improved upon the original technology and obtained more advanced equipment from Germany. It persuaded Schneider to grant it a licence to make a new switchboard, the only non-affiliate to be given this licence throughout the world. Schneider now sources components from Power Technics for various projects in the region. The firm plans to obtain ISO 9000 certification in 2000. It started exporting on its own to the region about four years ago, and its exports now account for around 15-18 per cent of sales.

The firm invests heavily in training its employees. However, the government provides no incentive or tax deduction for in-house training to Kenyan firms, despite repeated representations. It provides external training financed by the training levy, but Power Technics finds such training irrelevant to its needs. The MD has also proposed to improve the quality of university training by getting firms to sponsor students and providing practical experience of industry; the government should meet part of the costs involved. India has such a scheme and it is considered very successful.

Its major competitive problems include import tariffs (15 per cent) on major components like circuit breakers (which are too sophisticated and scale intensive to make locally): these tariffs are set at the same level as on final products. It cannot obtain tariff rebates on imported components for export and so suffers a cost disadvantage (import content is around 50 per cent). The inability to obtain tariff drawbacks on exports by firms that sell mainly to the domestic market may be a significant constraint to future export development and diversification.

Infrastructure is expensive and unreliable. It took the firm one and half years to get a telephone connection. It has its own water supply and generator, both raising costs. Security is very expensive. Otherwise labour costs are low: the firm pays $73 per month for unskilled workers and $200 for experienced skilled workers. Fresh graduate engineers receive $333 and engineers with five years' experience $670. These salaries compare well with countries like India and are well below salaries in South East Asia.

In spite of these problems, the firm has built up substantial sheet metal working and electrical system design capabilities. Its positive attitudes to technology and training mark it apart from the bulk of local manufacturing firms.

These exceptions apart, there is surprisingly little technological activity in Kenyan enterprises. The tradition has long been to passively import (simple) technologies and use them at low levels of technical efficiency with expatriate skills. Capital goods and design engineering are almost all foreign. These weaknesses mean that technological learning and diffusion are limited. Formal R&D in industry is confined to a very few large enterprises, but even here it is fairly marginal. The employment of trained engineers is very low, and in-house training is limited to creating the basic skills needed to operate the equipment. While liberalization has induced firms to upgrade their capabilities, the effort remains inadequate. *The government does not offer any fiscal incentives for enterprise R&D; such expenditures are not even allowable as legitimate tax deductible expenses.*

Policy recommendations: The main focus of technology transfer policy has to be on *information provision* to enterprises, particularly SMEs, on sources, costs and appropriateness of foreign technologies, backed by the provision of *technical extension services* to help them absorb new technologies. In fact, it is impossible to separate technology support measures from those to assist in technology import. The importance of information on foreign technology cannot be overstated. Firms in developing countries, especially those not geared to export activity, find it difficult and costly to obtain the information they need on sources of technology. Mistakes are easy, and show up in poor technical performance later. The East Asian Tigers made strong efforts to provide up-to-date information to local enterprises on sources of technology import, with on-line databases in all major industrial centres. Information provision was backed by extensive support in terms of advice, finance, consultancy and marketing support: it is recommended that the same institution be in charge of these activities, or at least of coordinating them.

Productivity centres are a well-tried and effective means of raising the quality and impact of technology transfer to industry. These Centres should have the capacity not only to undertake detailed productivity analysis but also to help finance remedial measures and undertake effective marketing. They should adopt a *proactive* approach, with qualified teams visiting enterprises, offering free diagnoses and putting together *packages* of technology, training and finance (initially at low cost to the enterprise but over time moving towards full cost). The Taiwan Productivity Centre and the Industrial Technology Research Institute, and the Hong Kong Productivity Centre, offer good models.

Intellectual Property Rights (IPRs) remain a controversial subject, and deserve some discussion. IPRs are being strengthened the world over, backed by the TRIPS agreement reached under WTO auspices. IPRs have moved in effect from the World Intellectual Property Organisation to WTO, under the TRIPs (Trade-Related Aspects of Intellectual Property Rights) Agreement. While this Agreement contains exhortations to increase technology transfer to the least developed countries, its main objective is to strengthen the protection offered to innovators, largely from industrial countries. It specifies rules on standards for protecting specified IPRs, domestic enforcement procedures and international dispute settlement. The most important point to note about the shift of venue from WIPO to WTO is that *trade sanctions* can now be applied to countries deemed to be deficient protecting IPRs.[21] This gives it much more ‘bite’ than before.

The implications for the developing world are worrying (Box 17). While stronger IPRs may benefit the leading innovators in the developed countries, they can inhibit technological development in developing ones. They can raise the cost of formal technology transfers, by allowing technology sellers to impose stricter restrictions and by preventing copying and ‘reverse engineering’, the source of much technological learning in newly industrialising countries. The developing countries that are placed to benefit are those that have already built up strong technology bases (often by using lax IPR regimes). The strong protection of brand names lacks the justification of patent protection, in that it does not contribute even to greater innovation.

Box 17: The dubious case for strong IPR protection

IPR protection is based on the premise that innovative activity is seriously constrained if the fruits of the innovation cannot be reaped by the innovator. Thus, copyrights protect the rights of authors (books, music, software), trademark registration protects unique trade logos and symbols, and patents protect the rights of inventions with industrial applicability (products as well as processes). For the purposes of technology development activity, it is *patents* that are of most relevance.

Patents are supposed to spur innovation in a number of ways. First, they award exclusivity of use, sale and manufacture to the owner of the intellectual property thus compensating them for undertaking expensive and risky innovative activities. However, in exchange for this benefit, the owner must actually disclose the invention on the patent document for “anyone skilled in the art to be able to replicate”. Thus patents are a trade-off: a market distortion is created in exchange for disclosure of the information relating to the technology. This disclosure is intended to benefit society by disseminating new technologies and indeed encouraging competitors to invent-around it. Thus a second round of innovation is encouraged.

Advocating stronger IPR regime presumes that the positive impact of the appropriability incentive for the innovator and disclosure element for competitors outweigh the negative impact of the temporary market distortion, thus making IPR protection beneficial to society as a whole. Empirically, this is nearly impossible to test and remains to date a highly debated subject. Most developing

[21] The WTO Agreement on Subsidies and Countervailing Duties may also affect traditional means of supporting technological activity by subsidies. Although the Agreement excludes ‘fundamental research’ from its actionable provisions (i.e. governments may still subsidise research), the text leaves scope for interpreting what the limits of this are. In any case, R&D now comes under WTO scrutiny, and subsidies for research deemed non ‘fundamental’ could be limited in the future.

countries see themselves as users of technology rather than makers or new technology and consider it premature to adopt the western models of IPR protection. In fact, it is feared that technological catch up may be constrained if stronger IPRs are enforced in developing countries. They may raise the cost of technology import and restrict their ability to reverse engineer and learn by this process.

This argument has some merit. Historically, there has been a U-shaped relationship between GDP and IPR protection. The very low-income countries possess strong IPR regimes in the absence of a domestic industry lobby. The high-income economies protect IPRs very strongly, for obvious reasons. The middle-income countries offer the least protection for IPRs.

However, two important events may change the shape of things to come.

First, investment flows are seeking global destinations and the ability of firms to protect their knowledge assets is a critical determinant in choosing the destination. The regime dictating the appropriability of the returns to their knowledge assets can make the difference between using it to position themselves as leaders or losing out the lowest cost imitator.

Second, all members of the WTO that are signatories to the TRIPs agreement have now agreed to reform their IPR regimes by 2004. This is an unprecedented step and it remains to be seen what the eventual benefits of such universal protection of intellectual property will be. However, for now the main concern for policy makers is that IPR reform is a bitter pill to swallow for domestic industry and consumers.

The challenge will therefore be to help developing countries design policies and instruments that are first and foremost in line with their technology-follower positions and secondly, balance proprietary motives with access, efficiency and distributional considerations. This would entail attention being paid to drafting competition policy, price regulation, targeted subsidies or other transfer mechanisms that would help mitigate the potential negative effects of stronger ownership rights on intellectual property. Finally, alternate methods of encouraging local innovation may also need to be devised to fit particular needs, such as protection and compensation for uses of indigenous knowledge in certain societies.

Source: Based on Luthria (2000)

5.4 Stimulating R&D

The mature Asian Tigers lead the developing world in R&D effort. They adopted different strategies to promote a local ‘technology culture’ (Lall, 1996), in line with their different visions and political economy. Each has lessons to offer other developing countries, which can be drawn upon and adapted to local circumstances (Box 18).

Box 18: Stimulating R&D in Korea, Taiwan (China) and Singapore

Korea: The Korean government supported technological effort directly in several ways. Private R&D was directly promoted by a incentives and other forms of assistance. There were a number of *direct incentives*. These included tax exempt TDR (Technology Development Reserve) funds, which were subject to punitive taxes if not used within a specified period. The TDR funds could, however, be used for investment in the first venture capital fund (Korea Technology Development Corporation, launched with World Bank assistance) and in collaborative R&D with public research institutes. The government also gave tax credits for 125% of R&D expenditures as well as for upgrading human capital related to research and setting up industry research institutes. It allowed accelerated depreciation for investments in R&D facilities and offered tax exemption for 10 percent of cost of relevant equipment. It reduced import duties for imported research equipment, and cut excise tax on technology-intensive products. The KTAC (Korea Technology Advancement Corporation) was set up to help firms to commercialise research results; a 6 percent tax credit or special accelerated depreciation provided further incentives.

The import of technology into Korea was promoted by further tax incentives: transfer costs of patent rights and technology import fees were tax deductible; income from technology consulting was tax-exempt; and foreign engineers were exempt from income tax. In addition, the government gave *grants* and *long term low interest loans* to participants in ‘National Projects’, which gave tax privileges and official funds to private and government R&D institutes to carry out these projects. The Korea Technology Development Corporation provided technology finance.

However, the main stimulus to industrial R&D in Korea came less from specific incentives than from the *overall strategy.* This strategy created large firms, gave them finance and protected markets to master complex technologies, minimized their reliance on FDI, and forced them into export markets. This is why, for instance, why Korea now has 25 times higher industry-financed R&D as a proportion of GDP than Mexico. Mexico has roughly the same size of manufacturing value added but has remained highly dependent on technology imports. The Korean strategy of technology promotion has given its *chaebol* a strong base for entering into demanding mass-production industries (like automobiles, D-RAM chips or consumer electronics). Few other developing country enterprises can match them for their ability to master, apply and build upon technologies generated elsewhere, and to bear the high degrees of risk associated with such strategies. It has, as noted, also led to high levels of concentration in industrial R&D and to some inflexibility in its direction.

Taiwan: While the growth of Taiwanese R&D has some similarities to Korea, there are important structural differences (Levy, 1988). The Taiwanese government has a more arm's length relationship with industry and did not promote the growth of large private conglomerates*.* It started to promote the development of local R&D capabilities in the late 1950s, when its growing trade dependence reinforced the need to enhance local innovative effort to upgrade and diversify its exports. A Science and Technology Program was started in 1979, targeting energy, production automation, information science and materials science technologies for development. In 1982, biotechnology, electro-optics, hepatitis control and food technology were added to this list. The S&T Development Plan (1986-95) continued strategic technology targeting, aiming at total R&D of 2 percent of GDP for 1995; it did not quite achieve this — it reached 1.8 percent by that year.

Around half of R&D in Taiwan is financed by the government, though the contribution has come down over time. Private sector R&D has been weak relative to Korea because of the preponderance of small and medium enterprises (SMEs), which cannot afford the large minimum investments involved in much of industrial research. However, enterprise R&D has risen over time as some local firms have grown and (like Acer and Tatung) become significant multinationals. Such R&D has been encouraged over the years by a variety of incentives. These include the provision of funds for venture capital and financing for enterprises that developed 'strategic' industrial products (of which 151 were selected in 1982 and 214 in 1987). They cover measures to encourage product development by private firms by providing matching interest-free loans and up to 25 percent of grants for approved projects. There is full tax deductibility for R&D expenses, with accelerated depreciation for research equipment; special incentives for enterprises based in the Hsinchu Science Park (with government financial institutions able to invest up to 49 percent of the capital). The government also requires larger firms to invest 0.5-1.5 percent of sales (depending on the activity) in R&D investment. The government has launched large-scale research consortia, funded jointly with industry, to develop critical products such as a new generation automobile engine, 16M DRAM and 4M SRAM chips.

As in Korea, the main drive for rising R&D in Taiwan came from export-orientation combined with measures to guide enterprises into more complex activities and reduce their dependence on technology imports. While Taiwan's 'lighter' industrial structure constrained the growth of private sector R&D in comparison to Korea, this was also a source of strength — Taiwan's innovative capabilities are more flexible and market-responsive, and much more broadly spread.

Singapore: The Singapore government launched a S$2 billion five year technology plan in 1991. A number of sectors (information technology, microelectronics, electronic systems, materials technology, advanced manufacturing technology, energy and water resources, environment, biotechnology, food/agrotechnology and medical sciences) were selected for development. An R&D target of 2% of GDP by 1995 was set; as with Taiwan, however, the target was not met (in Singapore's case by a larger margin). The new science and technology plan, launched in 1997, doubled S&T expenditures, to S$4 billion over 5 years, of which 30% is directed to strategic industries picked by the government.

There are several schemes to promote R&D by the private sector. The Research Incentive Scheme for Companies (RISC) gives grants to set up 'Centers of Excellence' in strategic technologies, and is open to all companies. The R&D Assistance Scheme (RDAS) gives grants for specific product and process research that promotes enterprise competitiveness, and is also open to all companies. The Cooperative Research Program gives grants to local enterprises (at least 30% local equity) to develop their technological capabilities by working together with universities and research institutions. The National Science and Technology Board initiates research consortia to allow companies and research institutes to pool their resources for R&D, and five consortia are already in existence (on marine technology, aerospace, enterprise security architecture, digital media and advanced packaging). The Innovation Development Scheme (IDS) provides a 50 percent grant to all promising innovation projects; the latest round provided S$130 million to 90 companies, local and foreign, in April, 1997.

According to the government, these schemes have succeeded in raising the share of private R&D to 65% of the total. The Singapore government also plays a catalytic role in promoting selected technologies. One example is biotechnology, where it has set up a high-powered research institute to launch research and attract contracts from leading MNCs.

In *Kenya*, by contrast, there is little awareness in industry of the need for in-firm technological effort. Most firms import technology and use it passively, often at well below international best practice levels. When the technology changes, they resort to further imports but again do little to master it. The Asian Tigers encouraged their firms to import new technologies and to invest in strenuous efforts to absorb, adapt and improve upon them. Only by these efforts could the firms reach international competitiveness, even though they were not (until recently, in any case) innovating at the frontier. Such a 'technology culture' does not exist in Kenya – and many other developing countries – and the government does not make any efforts to stimulate it. For instance, there are no fiscal incentives for enterprise R&D, which is not even allowable as a tax-deductible expense. In 'latecomer' Asian Tigers like Malaysia and Thailand, where the government is desperately trying to develop a 'technology culture', R&D is given 150-200 percent tax subsidies.

It would be advisable for governments of most developing countries to *accept enterprise R&D as a tax-deductible expense*, and to consider *granting a modest subsidy of 125%* (that is, a firm spending $100 on R&D receives $125 from the government). However, tax incentives are unlikely by themselves to stimulate much technology upgrading. In the absence of *demand* for R&D from enterprises, a few large firms or foreign affiliates would take up most of the subsidy. These are firms that would conduct R&D in any case and do not need the incentive. To encourage a net addition to R&D effort, it is vital to persuade firms to launch new technological activity. This requires *concerted information and persuasion campaigns,* backed by prizes and targeted measures to ensure that technology consciousness diffuses from the leaders to others. The government should therefore select leading technology performers as *technology models* for the rest of industry, showing to others how technology can be improved or developed locally and how it helps to build competitiveness. *Industry associations* can play a major role in this, as they did in the Asian Tigers.

Another recommendation for most developing countries is that the government set up a *Technology Fund to co-finance R&D by industry* (on a 50-50 basis). The Technology Fund should give resources to companies as a conditional loan, to be repaid by successful ventures and written off otherwise. While this raises the risk of losses if a large proportion of the projects fail (enterprises will not, however, deliberately 'take the government for a ride' if they are required to spend half the money), experience suggests that the risk in quite small. Similar funds have been tried, with considerable success, in Turkey and India, both in the context of World Bank financed Industrial Technology Projects. Each technology proposal was carefully vetted and monitored by experienced industry and research people and the large majority turned out to be commercially viable. In India, the project made R&D collaboration with research institutes a condition of the loan (see Box 6 above), but not in Turkey, where it could be entirely internal to the firm.

There turned out to be a surprisingly large latent demand among private enterprises for R&D support. Winning research projects became very prestigious in both countries, and helped launch a more general awareness that 'R&D can pay' even in less-industrialised economies.

International support for R&D, where available, can also play an important role. Take again the case of *Ireland* (Bell, 2000). During the 1980s, the amount of EU funding available for university and company research grew dramatically as the Union set up its Framework Programmes. This provided incentives for reorientation of university efforts towards industrially relevant issues. From the end of the 1980s, a number of 'Programmes in Advanced Technology' (PATs) were set up. These are generally described as 'technology transfer' programmes, but only BioResearch Ireland can be said to fulfil this function in the traditional sense of transferring knowledge from the research sector directly into commercial production. BioResearch has had some successes with biotechnology test kits and similar small-scale innovations. The Advanced Manufacturing Technology PAT functioned as a problem-solving support service to both local and multinational plant in Ireland, tackling questions such as logistics, choice of manufacturing technology, and so on. In many cases, it has strengthened the position of Irish managers in the multinational plant, helping them achieve and demonstrate high levels of performance in competition with their companies' plant in other countries. Other PATs have provided a mixture of more academically based problem solving and training. In the case of the telecommunications PAT there was little pretence that the programme was other than an extended postgraduate training programme, to satisfy the huge demand for software and telecommunications engineers that arose in the 1990s as these industries took off in Ireland.

Irish spending on scientific research was minimal up to the late 1990s. Excluding medicine, the total available for project and postgraduate grants (that is, the equivalent of the US National Science Foundation funding) to the entire university system in 1996 was under £I 5 million (about US$ 7.5m). From 2000, a £2.2 billion investment programme has been launched to strengthen Ireland's scientific base. Much of the investment is going into IT and biotechnology, which were prioritised in the national Technology Foresight exercise. Investment is focused in a fashion perceived to improve the enterprise environment and to be industrially relevant. While the linkages with industry will often be indirect – not least, through the transfer of manpower over time – this is not 'science for its own sake' but science with an economic purpose.

5.5 Attracting FDI

The developing countries that will receive most FDI in the emerging economic and policy setting are those that allow TNCs to set up facilities able to withstand global competition. This means that the host country has to provide *competitive immobile assets* – skills, infrastructure, services, supply networks and institutions – to complement the mobile assets of TNCs. While transport costs and taste differences mean that large markets will continue to attract more investment than small ones, few countries can afford to take a continued inflow of FDI – especially high quality, export-oriented FDI – for granted. This means that the ultimate draw for FDI is the economic base: FDI incentives and targeting cannot by themselves compensate for the lack of such a base.

The East Asian experience, particularly of countries like Malaysia and Philippines, suggests that FDI can flow into high technology activities can happen without any particular government strategy. In their case, it was largely a matter of good luck and welcoming FDI policies. High-tech TNCs had already established a base in Singapore. The rise of the semiconductor industry and the need for cheap labour for assembling and testing the devices had led US companies to look overseas. Over time, Japanese and other firms joined in this quest (helped by the rise of the Yen in the mid-1980s), and the tendency spread to a number of other export-oriented electronics activities. Countries with low wages, stable macro regimes, good EPZ facilities, English speaking workers and attractive FDI incentives were able to attract investments relocating from the developed countries as well as from Singapore. Apart from these general attractions, therefore, FDI targeting did not play much of a role.

However, the surge of high-tech export-oriented FDI did not spread to other parts of the developing world – countries in South Asia, North Africa and Latin America that played host to TNC assembly for export continued to concentrate on garments and other simple products. The main exception was Intel's investment in Costa Rica (Spar, 1998). Within South East Asia itself, while TNCs invested in automation and skill creation in their high-tech assembly operations, sustained deepening of local content and technologies took place *mainly as a result of government interventions*. These interventions involved incentives for upgrading and supply side support for skill and infrastructure creation and developing local suppliers. Malaysia adopted Singapore-style strategies to induce firms to raise local content; however, this was mainly by attracting other TNCs rather than by upgrading a (relatively weak) local skill and industrial supplier base. There was some increase in TNC R&D activity, but not to the levels reached by Singapore. Other countries in the region did not adopt similar proactive strategies. As a result, high-tech TNC operations still remain fairly shallow in Thailand, Philippines and Indonesia. This shallowness constitutes an important constraint to their future industrial growth and competitiveness, and their governments are seriously concerned to improve their FDI targeting and upgrade local skills and supply capabilities.

There is thus a strong case for policy interventions both to attract higher quality FDI and to induce investors to upgrade and deepen their activities over time. The economic rationale for interventions is three-fold: high transaction costs; deficient information on the potential of the host economy; and insufficient coordination between the needs of TNCs, the assets of the host economy and the potential to improve those assets.

First, *high transaction costs*. While most FDI regimes are converging on a common (and reasonably welcoming) set of rules and incentives, there remain large differences in how these rules are implemented. The FDI approval process can take several times longer, and entail costs many times greater, in one country than another with similar policies. After approval, the cost of setting up facilities, operating them, importing and exporting goods, paying taxes, hiring and firing workers and generally dealing with the authorities, can differ enormously.

Such costs can *ceteris paribus* affect significantly the competitive position of a host economy. An important part of competitiveness strategy thus consists of reducing unnecessary, distorting and wasteful business costs. This affects both local and foreign enterprises. However, foreign investors have a much wider set of options before them, and are able to compare transaction costs in different countries. Thus, the attraction of TNCs requires not just transaction costs be lowered but also, increasingly, that they be benchmarked against that of competing host countries. One important measure that many countries are taking to ensure that international investors face minimal costs is to set up one-stop promotion agencies able to guide and assist them in getting necessary approvals. However, unless the agencies have the authority needed to negotiate the regulatory system, and unless the rules themselves are simplified, this may not help. On the contrary, there is a risk that a "one stop shop" becomes "one more stop".

Second, despite their size and international exposure, TNCs face *market failures in information*. They collect considerable information on potential sites, on their own as well as from consultants and other foreign investors. However, their information base is not perfect; the decision making process can be subjective and biased. "Prospective investors, even the largest firms, do not always conduct systematic world-wide searches for opportunities. The search for opportunities is a bureaucratic process whose initiation and direction may be swayed by many factors, including imperfect information and skewed risk perceptions. Most companies consider only a small range of potential investment locations. Many other countries are not even on their map" (IFC/FIAS, 1997, p. 49).

Taking economic fundamentals as given, it is worthwhile for a country to invest in altering the perception of potential investors by providing better information and improving its 'image'. However, such promotion efforts are skill-intensive and expensive. They need to be carefully mounted, and they should be targeted to maximise their impact. Targeting can be general (countries with which there are trade or historic connections, or which lack past connections but are ripe for establishing them), industry specific (investors in industries in which the host economy has an actual or potential competitive edge), even investor specific. Targeting or information provision is not the same as subsidies or fiscal incentives: incentives play a relatively minor role in a good promotion programme, and good long-term investors are not the ones most susceptible to short-term inducements. The experience Ireland, Singapore and more recently Costa Rica

(Spar, 1998), suggests that promotion can be extremely effective in raising the inflow of investment and of raising its quality.

Third, effective promotion should go beyond simply 'marketing a country' into *coordinating the supply of immobile assets with the specific needs of targeted investors*. This addresses potential failures in markets and institutions for skills, technical services or infrastructure in relation to the specific needs of new activities targeted via FDI. A developing country may not be able to meet such needs, particularly in activities with advanced skill and technology requirements. The attraction of FDI in such industries can be greatly helped if the host government discovers the TNC's needs and meets them. As Costa Rica illustrates, the fact that it was prepared to invest in training to meet Intel's skill needs was a major point in attracting the investment (Spar, 1998). Singapore goes further, and involves TNC managers in designing its on-going training and infrastructure programmes, ensuring that it remains attractive for their future high technology investments. The information and skill needs of such coordination and targeting exceed those of promotion per se, requiring the agency involved to have detailed knowledge of the technologies involved (their skill, logistical, infrastructural, supply and institutional needs) as well as of the strategies of the relevant TNCs.

5.6 Strengthening technology institutions

We have already reviewed above the need for strengthening technology institutions like standards and metrology, R&D and SME extension. There is little to add here but it may be interesting to reproduce the author's recommendations for infrastructure strengthening to the Tanzanian government in 2000 (Box 19). This gives a flavour of the policy needs in a least-developed country if it is to start supporting technology development in industry.

Box 19: Recommendations on Tanzanian technology infrastructure

The picture for Tanzanian technology support institutions is dismal. The infrastructure is small and largely ineffective. It is poorly funded and motivated and has weak (or no) links with industry. Its ability to develop, adapt and disseminate industrial technologies is weak. It seems to have little awareness of the competitive needs of Tanzanian industry, even less of how new technologies can be introduced to potential users. There are some attempts to reform and improve the main institutions, but in the absence of government support, the culture of dependence on external aid and the lack of involvement by the private sector are important handicaps.

Technology policy formulation is uncoordinated and the main institution in charge of S&T policy making, COSTECH, is weak and unable to influence the agencies in the government that conduct R&D. Much of the R&D is in any case irrelevant to industrial needs. The Standards Bureau is well staffed and motivated, but lags in technological terms and is under-funded. None of its laboratories are internationally accredited, and it is unable to meet many industrial needs. TIRDO does not produce any significant technological benefits for industry, though if performs some useful technical functions. It tends to lack credibility with private firms, and does too little to reach out to them. SIDO is even weaker. IPI has turned into a manufacturing rather than technology development institution. This infrastructure is clearly unable to help an industrial sector with weak technological capabilities facing a growing international competitive threat. The gap between local institutions and world best practice is very large and growing with time.

Part of the problem of any technology infrastructure institution in a country like Tanzania is the technological backwardness of private industry. With little technological dynamism in industry, it is very difficult for government institutions to 'pump out' technology to firms. The same lack of technical skills and information that afflicts industry also afflicts the institutions, despite their access to international sources. Public ownership, low salaries, inefficient management and lack of incentives make a bad situation worse. At the same time, in the absence of private technological activity, there is a greater burden of responsibility on the public institutions to undertake more technological effort and ensure its effective delivery.

Some specific recommendations for the main institutions are:

TBS: The laboratories of the Tanzania Bureau of Standards (TBS) need to be internationally accredited and the Bureau has to development the capability to accredit independent testing laboratories and so help a private technology services market to develop. TBS is trying to upgrade its food and chemical laboratories for accreditation, but this needs considerable new investment and training (new laboratory equipment for 7 laboratories is estimated to cost around $750 thousand). It also needs to extend the range and coverage of its facilities to serve potential or emerging industrial activities. The government should carefully consider making this investment, since efficient, modern and internationally accepted standards are essential for technology development. Further investment would be needed for TBS to develop its own accreditation capabilities.

TBS should consider encouraging testing to become a private service activity and focusing on its core standard setting activities. It should also be provided the resources and incentives to undertake a more aggressive quality campaign, particularly to reach SMEs that lag badly in quality management and standardisation. Private consultants on quality management in Tanzania need to be encouraged – at present none exist. There are also no university courses available in standardisation and quality management in Tanzania (many go to India for training). Capabilities are also limited in metrology, particularly in the energy field. As with all public sector technology institutions, salary levels are inadequate for attracting and retaining high quality technical personnel. TBS needs a more aggressive approach to reaching out to enterprises – perhaps a change in the management culture of the organisation is called for.

TIRDO: The Tanzanian Industrial Research and Development Organisation (TIRDO) has not been very effective in improving industrial technologies in Tanzania. It has become a passive and rather demoralised body, with low salaries and minimal technological development activity. Its 'image' remains poor with industry and its facilities are obsolete even for the simple technologies in use in the country. Yet TIRDO is in a critical position in Tanzania to help industry with technology import, upgrading and capability building. It is vital to revive, strengthen and broaden its capabilities and make it really relevant to industry. The revival of TIRDO would require a thorough overhaul of its organisation, management, staff and skills, and should be based on a comprehensive strategic plan developed in consultation with the private sector. The focus of the organisation should shift to providing services in demand by firms, with appropriate incentives to staff to reach out and discover what is needed.

SIDO: The Small Industries Development Organisation (SIDO) is in an even worse state than TIRDO. However, in an effort to regenerate itself, it has appointed a new Board and is seeking further foreign assistance. However, as with TIRDO, the issue is not just to pump in additional resources but to thoroughly restructure and reorient the institution and make it relevant to SME needs. *This again needs a strategic plan that looks at its approach, staff and capabilities.*

To start with, there is no need for SIDO to take on such functions as operating industrial estates. These can be easily owned and managed by private entrepreneurs. SIDO should focus on reaching SMEs with programmes of technology, marketing, training and marketing assistance. This requires much greater skills, dedication and resources. The government has to commit itself to providing adequate funding, on a long-term basis, for SIDO, reducing its dependence on variable foreign resources. As with the other institutions, the salary and incentive structure for staff has to re-examined and improved. Training and equipment have to be greatly improved.

There are two general approaches that SIDO should use in addition to reaching out to SMEs: *promotion of subcontracting* (between large firms and SME suppliers) and the *strengthening of SME clusters*. While the importance of subcontracting is recognised, there is in fact relatively little interaction between large and small enterprises in Tanzania, perhaps reflecting weaknesses on both sides. SIDO should focus on improving the supply and linkage capabilities of SMEs, providing them information and assistance specifically to meet the needs of large firms. In this effort it should enlist the advice and help of large firms, perhaps using their procurement managers to give assistance on a part time basis (Singapore used this very effectively to promote suppliers to high-tech TNCs).

In this context, it is relevant to quote from a recent study comparing technology policies in Argentina and Canada (Box 20). Argentina is interesting because at one stage it was one of the most advanced industrial economies in the developing world, and was endowed with a large supply of technical and scientific manpower. However, it failed to adopt progressive and well-focused technology policies. Along with macroeconomic mismanagement and hasty liberalization, this has contributed to structural weaknesses in industrial technology and competitiveness.

Box 20: Comparing technology policies in Argentina and Canada

In productivity terms, Canada and Argentina have followed a similar path up the Second World War. By 1940-1945, a major gap opened. Many factors contributed to that gap, but the creation and nurturing of a national system of innovation by Canada is certainly one of the major ones. During the last decades Canada has created a major group of research universities, government laboratories and science and technology policy comparable to those of other developed nations. Those universities and government laboratories trained a highly skilled manpower, while technology and science policy stimulated private firms to conduct R&D and absorb some of the many knowledge outputs of university and government laboratories. As a consequence, entirely new industries were created, many of them became large producers and exporters, while more traditional industries were rejuvenated through innovation. The result of so many efforts was that Canada joined the exclusive club of industrial nations, and its output indicators, both for science and technology, rank Canada among the most performing countries in the world. These efforts yielded results in the structure of exports, in the generation of new firms, in job creation, and in the employability of its labour force, as well as in the quality of life of its population.

Conversely, since the mid 1970s Argentina abandoned its efforts in institution building, and *laissez-fai*re replaced the few efforts that had characterised the previous decades. The high level of political and economic instability contributed to this situation; the previous history of science and technology policies in Argentina where the failures have been more frequent than successes also accounts for it. Only in the last few years some interest in programming the training of human resources and institution building for science and technology has reappeared in Argentina. Most often, the past efforts were scarce and rapidly abandoned, and no accumulation of experience took place. Policies were launched and discarded without real attempts at their evaluation, modification and enhancement. Thus, no learning process took place in the public sector in the design, assessment and fine-tuning of science and technology policies. Also, lacking appropriate incentives, Argentinean firms did not generally become dynamic learning organisations, giving priority to innovatory activities. At best a few large corporations can import and adopt foreign technology to their needs, but few are able to design new products or processes, or use knowledge generated in universities or government institutes.

Some of the most successful programs in Canada (as elsewhere in the industrialized countries) has been a set of horizontal technology policies. These were designed to provide incentives to established firms (such as tax credits for R&D), stimulate innovation in SMEs (such as the technological counsellors program), and create new technology-based firms (such as policies for venture capital). These policies have always been assessed and improved in light of the accumulated experience. They have become permanent policies whose positive results are not always immediately visible.

Argentina has started to catch-up the institutional gap, among other things, by adopting two of these policies. Our work suggests that it should maintain and broaden the scope of its technology policies by adopting new ones, as well as investing additional resources in enlarging the breadth of the newly created ones.

Beyond the specific comparison of technology policy instruments in both countries, it is important to bear in mind the context in which they are applied. In Canada, the tax credit and the other instruments considered here are a component of a wide set of science, technology and innovation policies in which more focused and sectoral policies are also included. These and other educational, training and cultural policies have a significant consensus in the country. All these initiatives are also linked to more general policy instruments geared to favour the transition towards a knowledge-based society, following an implicit or explicit systemic approach.

In Argentina, the technological upgrading of the productive sector and the emerging consensus in favour of an active technology policy instruments in the 1990s are certainly positive factors. However, the impact of these policy initiatives in reverting the critical situation in which public institutions are doing their science and technology activities and in changing the patterns of behaviour in private firms is hard to predict. Although the instruments discussed in this paper are not the only ones that are being applied, so far innovation policies are incipient and limited in their scope. It is important to sustain and improve them, to enlarge their scope and make them more pro active. But they are clearly insufficient. They must necessarily be linked to a more complex set of systemic competitiveness and innovation policies aimed at transforming the productive structure of Argentina into a more knowledge based one.

Source: Chudnovsky, Niosi and Bercovich (1999).

6. Conclusions and Policy Implications

6.1 Summing up

The evidence suggests growing diversity in industrial and technological performance in the developing world in the face of liberalization and globalisation. This is an unfortunate but perhaps intrinsic feature of the new technology-driven economy. Skill development, industrial specialisation, enterprise learning and institutional change create *cumulative* and *self-reinforcing processes* that promote or retard further learning. Countries set on a pattern with a low technology, low skill and low learning specialisation find it increasingly difficult to change course without a concerted shift in a large number of interacting markets and institutions. Economic liberalization may help them to realise their static comparative advantages, that is, those based on inherited endowments like natural resources and cheap unskilled labour. However, it may not lead them to develop the more *dynamic* (skill and technology based) advantages they need to sustain growth and structural change. Thus, they may become outsiders in a world of rapid and accelerating technological change, new skill needs and integrated production systems. They may suffer from long-term ‘immiserising’ growth, having to export larger amounts of products facing static or declining prices to import given amounts of foreign services and products.

The insiders are the relatively few developing countries that have been able to launch themselves on a sustainable high-growth path. The insiders also differ, depending on the strategies adopted. We may distinguish two general strategies: *autonomous* and *FDI dependent*. Autonomous strategies – as demonstrated by Korea and Taiwan – entail a great deal of industrial policy and accompanying interventions in factor markets and institutions. They lead to a massive development and deepening of indigenous skills and technological capabilities, with the national ability to keep abreast of new technologies and for domestic enterprises to become significant global players in their own right.

FDI dependent strategies comprise two sub-strategies, *targeted* and *passive*. Targeted strategies – as in Singapore – also entail considerable industrial policy, but the intensity of government interventions is lower than with autonomous strategies (Lall, 1996). The sources of technical change remain largely outside, in the hands of TNCs; there is less need to intervene to promote learning in infant industries for this reason. However, industrial policy is needed to ensure the development of the relevant skills, capabilities and institutions required to ensure that TNCs keep transferring new technologies and higher value functions. Passive strategies involve less industrial policy in export-oriented activities to start with (though there may be intervention in domestic-oriented activity). TNCs are attracted mainly by low wages for unskilled or semi-skilled labour and good infrastructure, given a conducive macro environment and welcoming policies to FDI.

Subsequent dynamism and upgrading depend on whether TNCs are induced from simple assembly activities into more advanced, value-added activities with greater local 'roots'. This involves increasing policy intervention to deepen the local skill and supplier base and to target FDI itself. Without such capability development, the initial spurt of growth may well peter out – rising wages will erode the static competitive base. This is the danger facing a number of developing countries (like Bangladesh, Mauritius or Morocco) that have done well out of the relocation of the clothing industry in building simple manufactured exports, but have not been able so far to upgrade into more complex or technology-intensive activities.

Simply opening up to free trade and investment flows is not an adequate strategy for countries at the low end of the technology ladder. Stabilisation and liberalization can remove the constraints to growth caused by poor macro management, inefficient public enterprises, high entry costs for private enterprises and restrictions on FDI. However, it cannot by itself allow the economy to build more advanced capabilities, to escape a 'low-level equilibrium trap'. Evidence on liberalising countries like Kenya, Tanzania, Zimbabwe and Ghana shows that after an initial spurt of growth, economies with static capabilities slow down as their inherited advantages are exhausted (Lall, ed., 1999). The initial spurt comes from using existing unused capacity as imported inputs and spares become available. As import competition in the final product market increases, however, enterprises find it difficult to cope and close down or withdraw into non-traded activities. Without any strategic support from the government, they find it difficult to bridge the gap between their skills, technologies and capabilities and those needed for international competitiveness. New enterprises find it even more difficult to enter complex activities with even more stringent skill and technology requirements. There is a danger, therefore, that industrial structures in low-income countries with passive industrial policy regress into simple activities that do not provide a basis for rapid growth. This is one important reason why liberalization has had such poor results in Sub-Saharan Africa. Liberalization has also led to technological regression in many countries of Latin America, with relatively weak growth and competitive performance. These countries often have a large base of capabilities in such industries as food processing and automobiles, but find it difficult to move into dynamic high-tech activities.

6.2 International rules

The rule-setting part of the international system that deals most directly with development (the Bretton Woods institutions and, increasingly, WTO) has so far been more concerned with *facilitating* globalisation rather than helping countries *cope with* its demands. This approach has been based on the implicit premise that markets and rules to promote market forces will accomplish both objectives: liberalization is the best policy response for all countries. As a result of external pressures as well as domestic strategic changes, there has been considerable liberalization in the developing and transition world. Governments are withdrawing from direct ownership of productive resources and also from the provision of a number of infrastructure services. They play a steadily diminishing role in the allocation of productive resources. The ultimate objective of the current phase of reforms is a liberal production, trading and investment framework where the driving force is private enterprises responding to market signals.

The new rules applied to technology – such as TRIPS – aim principally at making life easier for TNCs: make policies clear and predictable, remove all obligations apart from maximising company profits and offer the strongest possible protection for intellectual and commercial property. Their objective is to reduce transaction costs and uncertainty for global operators, by reducing the freedom of action for governments to intervene in the national interest. Thus, they allow little scope for the kind of exclusion, selective targeting and performance requirements that allowed countries like Korea and Taiwan to build up their technology systems. They assume, in effect, that what is good for the TNC (and developed country innovators, the two are often the same) is equally good for a developing host economy, i.e. there are no market failures causing divergence between private and social interests. As a logical consequence, they impose no rules on what TNCs can or cannot do, while they constrain the ability of governments to affect market driven resource allocation.

Given their assumptions, all that is needed to extract the maximum welfare benefits from technology and investment flows is to have clear, stable and ‘fair’ rules of the game. It is accepted that these rules include strong competition policy within each country, to counter obvious anti-competitive behaviour by all firms. However, such rules fail to provide policy tools to deal with other forms of market failure apart from anti-competitive behaviour. There are many other market and institutional deficiencies on which governments could act to improve welfare and raise their growth potential.

This does not mean that the existing rules close *all* relevant policy options. They still leave scope for a number of actions, such as attracting investments to particular sectors, raising the quality of human capital, subsidising R&D, or strengthening technology institutions: these now comprise the core of ‘competitiveness strategy’ in many advanced economies. Developing countries clearly have to explore how much latitude they retain and design strategies that can maximise their growth enhancing effects. However, problems remain. First, some permissible policies may well be constrained in the near future. Second, the scope of currently permissible policies may be too narrow for development needs. They make it impossible to promote infant industries or to discriminate between local and foreign investors. This belies the fact that entry into many complex activities faces high cost, risk and externalities, or that local firms and TNCs face different factor markets and undergo different learning processes. Providing a 'level playing field' in the presence of such imperfections creates rather than removes distortions. There is no case in economic theory for enforcing such rules. In practice, there may be arguments in favour of adopting simple universal rules, but experience shows that policy interventions do work and that governments can improve their intervention capabilities (Lall and Teubal, 1998).

The emerging international rules aim to reduce the transaction costs, uncertainty and external obligations associated with international business. It is argued that, *ceteris paribus*, they will raise the quantity and quality of FDI in developing countries and provide the investment, skill and technologies needed for development. However, *ceteris* is not *paribus* where FDI flows are concerned. Given the deficiencies in domestic skills, capabilities and institutions in 'marginalised' economies, it is not clear that policy liberalisation by itself will stimulate significantly larger amounts of direct investment. Will the new policy regime still make things better than they were before? This is far from clear. New FDI does flow to developing economies that are recovering from instability and bad macroeconomic policies, but most of it goes into primary activities or privatised enterprises. Once this tapers off, FDI often does not continue in the productive sectors, even less so in new, high value-added – catalysing this remains the task of national development policies.

The risk, not sufficiently recognised, is that the *new rules can constrict those development policies*. They open countries to international trade and FDI but stop them from adopting some policies that can allow them to benefit fully from them. However, these were confined to national or financial security, balance of payments crises and other exceptions to be negotiated individually, hardly providing for a systematic use of strategy to build national capabilities and extract greater benefits from FDI. A level playing field does not make much sense when the players are very unevenly matched and when it actually prevents the weaker players from improving their game.

It is important not to over-state the case for industrial policy. Many interventions to promote development have clearly had a poor record, constraining rather than promoting growth and welfare. Giving greater play to market forces will contain many of the inefficiencies and rent seeking inherent in government intervention. However, as noted, simply opening up to market forces does not deal with many structural problems of development. The most successful developing countries in recent economic history (the Asian NIEs) intervened intensively in markets, with many different strategies to build up their competitive capabilities. Their experience suggests that there is a significant role for government in providing the 'collective goods' needed for sustained development. The issue is not *whether* governments should intervene, but *how*.

6.3 Constraints to good policy

The 'bottom line' in all strategies is how well they can be implemented *in practice*. While it is not difficult to establish a theoretical case for government policies to promote competitiveness and dynamic growth, and to show how other countries have done this successfully, governments differ in their capabilities and the political economy within which they operate. It is therefore vital to bear in mind the risks of *government failure*. After all, the history of development policy is replete with cases of failed policies, and the current trend to liberalisation is partly a reflection of such failure. The main causes of government failure in mounting pro-active strategies are as follows.

Lack of Clarity of Objectives: Governments often have unclear or conflicting objectives in economic and trade policies. This make it difficult, or impossible, to design and implement a strategy which calls for a strong, unambiguous pursuit of efficiency and competitiveness and a sharing of these objectives with the main actors involved. 'Leaving it to the market' at least has the advantage that is imposes a clear set of priorities on policy makers and is easily understood by the actors. However, in the presence of market failures this may not be the best strategy. Even the implementation of essential functional policies entails a high degree of efficiency and commitment, as well as selectivity between competing demands. All governments have to make compromises with equity and other social needs and cope with pressure groups. All this requires clear objectives that are understood by all stakeholders in policy.

Clarity of objectives is, of course, a matter of political leadership and commitment rather than of economic analysis. There may nevertheless be different degrees of clarity and commitment. Korea, for instance, was very different in its political economy from Taiwan, where relations between government and business were much more arm's length — in the former, the government could therefore exercise a much greater degree of selectivity. But both shared the commitment to achieving export competitiveness, as do the very different regimes in the new Tigers. Given the other demands of selectivity (below), it would seem to be a basic condition that any government that undertakes industrial policy have a clear and well-publicised set of objectives where efficiency and export growth have top priority.

Lack of information: All strategies require information on technological and market parameters, and on local capabilities and institutions — this is often posed as one of the main constraints to selectivity. A government may not have access to better information than industrial firms, even if such information exists somewhere (for existing technologies, say, in more industrialised countries). Where the choice involves new technologies the necessary information is unlikely to exist anywhere. While the government is clearly better placed than individual agents to tackle coordination problems and externalities (Stiglitz, 1996), these may involve even more difficult information issues. These are very real dangers, calling for caution in devising selective export promotion strategies.

However, it is possible to over-stress the information problems in mounting strategies. Neoclassical economists, in particular, seeing strategy as a problem of finding unique solutions to a massive optimisation problem, find it difficult to conceive how governments can ever obtain and process adequately the requisite information (at the same time, they tend to overlook how their own assumptions minimise the problems that private agents face in this respect — when information is imperfect, the future uncertain and risks cannot be insured). This is not the right way to see the competitiveness problem. Given the various market failures and possibilities of multiple equilibria that exist in the real world, governments have to decide upon which path they set the economy upon without being able to evaluate in detail the costs and benefits of different outcomes. As Stiglitz (1966) notes "Good decision-making by the government necessarily involves making mistakes: a policy that supported only sure winners would have taken no risks. The relatively few mistakes speak well of the government's ability to pick winners" (p.162). *In the real world, the government does not replace a perfect market — it acts as a venture capitalist that takes risks.*

Most developing countries choose between technologies that are established elsewhere and, with some effort, they can obtain full information on the technological and skill parameters involved. This is much easier than 'picking winners' at the frontiers of innovation, the problem of industrial policy in advanced industrial countries. In effect, *between a reasonable range of technological choices*, it does not matter very much exactly which activities developing countries choose to promote. By mounting a coherent and integrated series of interventions it is *possible to create activities that are competitive*. This is precisely what the governments of the interventionist Tigers did. Each defined its own set of favoured activities (within the different strategic objectives it had chosen). Having done this, it mobilised factor and product markets with appropriate trade, industrial and other policies to guide enterprises and industries, imposing export discipline to ensure that the privileges granted were not wasted or abused. Mistakes were made, as with all private investments, but flexible and rapid response ensured that the costs were not very high. None of this was done, as far as we can tell, on the basis of sophisticated quantitative models or calculations, but by using simple guides. The most obvious one was 'follow Japan' or the immediate competitors. Others were to increase backward integration, tap high income-elasticities of demand for exports, maximise technological 'spread' effects, or establish a foothold in important new technologies. Their choices also at times reflected strategic rather than economic priorities.

This does not mean that *any* choice of activities would have worked equally well. The choices have, as noted, to be 'reasonable' — what does this mean? Given the incremental and cumulative nature of technological learning, the activities promoted had to be based on the existing base of skills and capabilities and the rate at which these could realistically be increased. The technologies developed had to have commercial applications, and the private sector that was to use them had to have the financial wherewithal to mount the necessary investments. The main demands were organisational rather than informational.

As far as information goes, the real challenge to developing countries lies in finding out the basic parameters of new technologies (efficient scales, sources of know-how and equipment, skill needs, international market size and access) and in predicting the availability of the local capabilities and suppliers. The mistake import substituting governments made was to ignore efficiency requirements and international markets, and to assume away local capability problems. In effect, they believed that the necessary capabilities existed within the country, or would be created automatically and without extra cost. The Tigers, on the other hand, tended to look carefully at scales, skills, supplier structures, technological effort, quality, market needs and so on, and to intervene to help firms develop the necessary capabilities. The procedure was not easy, but it was systematic and rational, unlike that pursued by import substituting regimes. The need to export forced technological jumps not to be too large or non-commercial (though some, particularly in Korea, appear highly risky).

Skills: Any competitiveness strategy is very demanding of technical and administrative skills, often in short supply in developing countries. The skills are needed to understand and devise strategies with strong technical content, and, more importantly, to implement and improve them over time, to communicate with the industrial sector, and to ensure that agency problems (below) are overcome. Of course, the need for skills is not uniform, and depends on the level of industrial development and the degree of selectivity aimed for. The more advanced the industrial base and the more detailed and adventurous the strategy, the higher the levels of skills involved. In countries with small and simple industrial activities, the strategies can be devised far more easily and their implementation may need a smaller range of technical skills. The degree of selectivity itself can be geared to the capabilities of the bureaucracy and the pace at which its information and training can be improved. In this context, it is important to note that administrative capabilities are not required only for selective strategies; it is just as important for the success of 'market friendly' policies, that have to provide for education, competition policy, infrastructure and so on.

Government skills are not given; they can be improved by training, selection, competitive salaries, promotion schemes and performance incentives (see World Bank, 1993, on the lessons of East Asia). The social status of the civil service is an important determinant of its confidence and ability to liase with the private sector. All these considerations are fairly obvious and mundane, but they are important nevertheless

— it is surprising how many governments tend to overlook them when demanding their bureaucrats to mount difficult and demanding tasks.

Agency Problems: Theory suggests that policy makers must devise suitable incentives and monitoring mechanisms to ensure that the ‘contract’ between them and their agents (mainly in the private sector) is enforced. While theoretical solutions may appear complex, it is possible to devise simpler practical ones. The Tigers did this in different ways: the most important and common one was, as noted, the use of export performance as the monitoring and allocation device (what the World Bank, 1993, calls ‘creating contests’), but there were others. Banks acted as agents of monitoring and implementing export policy. Regular meetings between industry and government permitted the inter-flow of information, backed by detailed industry and strategy studies. Close contact between the bureaucracy and industry was promoted, with personnel moving between the two. Korea’s promotion of a small number of *chaebol* allowed the government to limit the number of agents it had to deal directly with, and to use them as interlocutors with the rest of the industrial sector. Industry associations also played vital roles as interlocutors in all three interventionist countries.

Within the bureaucracy itself, there are means of ensuring better compliance. As noted, skills and information can be enhanced; internal incentive structures can also be improved to ensure that general objectives are met efficiently. Again, making bureaucrats responsible for meeting export targets can be an effective way of improving their commitment and incentives. Adequate reward and promotion systems are another.

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In E-Strategies for Technological Diffusion and Adoption: National ICT Approaches for Socioeconomic Development, ed. Sherif Kamel, 293-311 (2010), accessed June 20, 2019. doi:10.4018/978-1-60566-388-3.ch017. Export Reference.Â In that respect, developing nations are urged to keep pace regularly with the developments taking place in the developed world through the design and implementation of strategy, vision and detailed plans for universal access in terms of ICT literacy and its effective utilization for developmental purposes were ICT is promoted as a vehicle for development.Â This chapter describes the evolution of the ICT sector in Egypt over the last decade with One of the most important technologies to help reverse the productivity slowdown going forward is robotics.Â But the interesting question is how do national economies perform in robot adoption when controlling for wage levels? Figure 1: Robots Per 10,000 Manufacturing Workers, 20177. 800 700 600 500 400 300 200 100.