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Strategic Vision and Industrial Policies for the New Millennium

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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1. Introduction

The setting for industrial development is changing rapidly. The new millennium will see a set of parameters for manufacturing very different from the period in which industrialization in the developing countries of the Asia-Pacific region was launched (in the 1950s). This paper reviews this changing context and the ability of the region to cope (in building prosperity and competitiveness in industrial activities). Each country, or group of countries, faces new and serious challenges, but there are large – possibly growing – differences in the ability to cope and succeed.

Section 2 describes the main features of the new setting for industrial development. Section 3 shows how industrial competitiveness, as revealed in patterns of manufactured exports, is changing in response. Section 4 deals with the role of industry in the future. Section 5 analyses the need for new industrial strategies, focusing on the main determinants of success: technology, skills, direct investment flows and the policy context. Section 6 closes with implications for the role of government and international organizations.

2. The emerging setting for industrial growth

The new setting is a mixture of technological, economic and policy factors. We can simplify a complex reality by reducing these to the following four:

- Accelerating pace of technical change
- Globalization of production
- Liberalization of economic policies on trade, investment and ownership
- Changing international 'rules of the game' in economic life.

Accelerating Technical Change: So rapid and sweeping is technical change today that some analysts of technology see the emergence of a new 'technological paradigm' (Freeman and Perez, 1988). The 'paradigmatic' element of the change arises from the fact that it affects the entire spectrum of economic and social activity, changing modes of organization and behaviour and existing patterns of comparative advantage. Esser *et al.* (1996) describe the changes as follows:

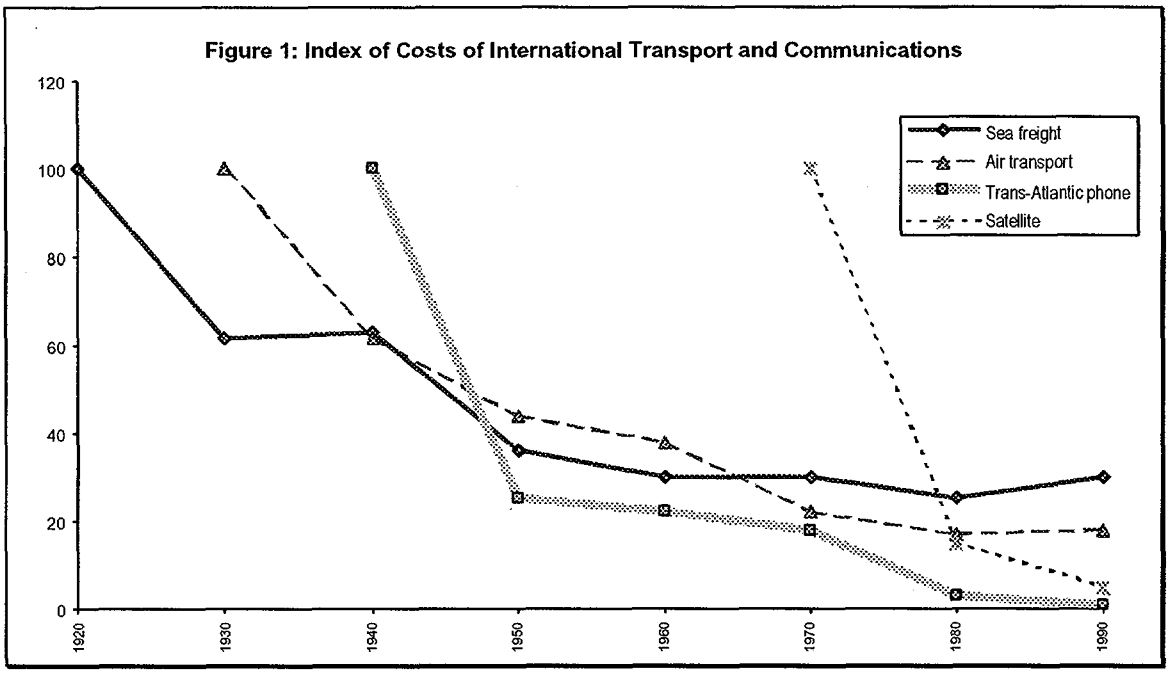
- "A new pattern of competition marked by knowledge and technology-based advantages; competitive advantages based on inherited factor endowments are losing their significance …

- "The emergence of new organizational structures characterized by less hierarchical concepts … firms are embedded in dense technological and productive networks (industrial clusters, industrial districts, business alliances, long-term contractual arrangements with suppliers).

- "Radical technical change gives rise to both a restructuring of old industries and a creation of new ones and to substitution processes that see traditional raw materials edged out by new ones

- "In the political sphere, the new pattern of competition requires active policies aimed at shaping new industrial locations. Their formulation and implementation is based on cooperative approaches that focus on the know-how provided by firms, science and the public sector (policy networks), in this way complementing the policy mechanism." (pp. 1-2)

Technical change is also changing the parameters of technology and product flows across countries. Flows of people, apart from short-term visitors, remain more controlled, but there is a significant increase in authorized migration of skilled, and the unauthorized one of unskilled, workers. Costs of transport and communications are falling drastically (Figure 1); an increasing portion of information and knowledge is available at negligible cost via the Internet. This is accompanied by an increase in the number of channels, speed and access of information transfer. Consequently, today's world is a very different one in terms of information and technology from that 2-3 decades ago in which current development strategies were thought up.



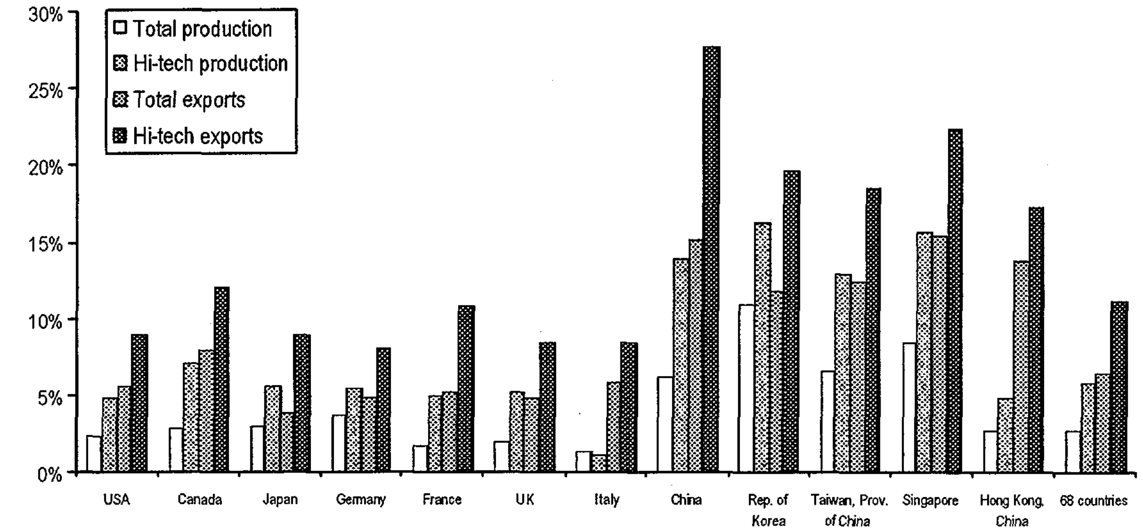
This has important implications for the nature of industrial activity, the flows of knowledge on which it relies and the marketing of the products that it makes. Industrial production itself is becoming more specialized, in that different functions are being hived off to different agents: many of its information related activities are being taken over by new enterprises. In addition, industrial production is growing in 'information intensity', quite apart from the massive increase in the use of computers by enterprises. 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."[1] The general rise in the share of high value services greatly strengthens this trend. The importance of services such as finance, communications, transportation and servicing to industrial growth and competitiveness is evident to all observers. The use of information and new services is as relevant to developing as to developed countries, at least to those that aspire to have manufacturing and service activities geared to world markets.

The use of new technologies, in particular information-based technologies, calls for more, better and newer skills (ILO, 1999, p. 39). The technological reasons for this are clear, but there are also organizational ones. New skills are entailed in setting up and working effectively with new forms of work organization and production systems. These skills have to be complemented with other changes: different attitudes to work, new occupational categories, new work relationships and new management systems. Skills are subject to *continuous* change, and the education system has to upgrade skills constantly in line with 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 specialized professional expertise with business and management skills… [Even for production workers] the trend is towards up-skilling and multi-skilling … It is not only that each job has experienced up-skilling, but the overall distribution of production jobs has shifted away from the less skilled to the more skilled" (*ibid.* p. 47).

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

The emerging system, while immensely productive, is enormously demanding and challenging. It leads to large shifts in the location of productive and innovative activity and comparative advantage. Technology intensive activities, those with rapidly changing products and processes, are growing faster than others in the leading industrial and developing countries (Figure 2). The ability to compete depends increasingly on the ability to incorporate new technologies into manufacturing and services. However, sustained growth calls for a shift in industrial structure from simple to advanced technologies. The 'bottom line' in the emerging paradigm is *competitiveness* – the ability of an economy to grow in an open market with advantages that yield rising wages, sustained employment creation and improved working conditions.

Figure 2: Growth rates of total and high technology production and exports, 1980-1995



Traditional modes of competition, based on low costs and prices, are being replaced by competition driven by quality, flexibility, design, reliability and networking (Best, 1990, calls this the 'new competition'). This change is not just in markets for advanced manufactures but also to mundane consumer goods like clothing, footwear and food products. Firms are specializing increasingly in different segments of the production chain, outsourcing segments and services to other firms to reap economies of scale and specialization. At the same time, the leading firms in most industries are broadening their field of technological competence to manage effectively the complexities of supply chain management and innovation. *Information flows, interaction and networking* are the new weapons in the competitive armoury. In technology-intensive activities these often include strategic partnerships with rivals and close collaboration with vertically linked enterprises. Competitiveness requires more of developing countries than providing cheap labour. The competitive advantage given by low wages for unskilled or semi-skilled workers is valuable, but only as a starting point. It can be temporary and evanescent, since it cannot support rising wages and incomes unless skills and technologies are upgraded to allow for efficient high value-added activities. The development of competitive capabilities is unevenly distributed, however. We analyze below how their main determinants vary in the region.

Globalization of production: Technical change and globalization are two aspects of the same phenomenon. The pace of innovation and its rising costs makes it necessary to aim at world markets to realize full returns. Lower transport and communication costs raise the intensity of competition and make it necessary to find the most economical sites to make different products or components and to serve different markets. Global production networks within transnational companies, in turn, leads to further collaboration between independent firms as specialization increases. However, globalization is a *highly uneven process*. Direct investment flows are very concentrated, with 10 developing countries accounting for over three-fourths of total FDI inflows into the developing world. Exports by developing countries are even more concentrated (below). Growing trade is not leading to a more even spread of participation or to a more equitable distribution of underlying comparative advantages. Similar inequities exist in the generation of new knowledge. A handful of countries continue to dominate innovation, and within them the creation of productive knowledge is in the hands of a relatively few large enterprises. There is new entry, but from a very small number of countries; the vast majority of developing countries remain on the periphery.

The main innovators are also generally the world's largest and most dynamic multinationals, the main engines of globalization. But this integral link between innovation and globalization does not mean that the *knowledge base* is spread more widely than before. The technology that enterprises deploy in each location depends on local abilities to absorb and use that knowledge at 'best practice' levels. Those with low capabilities receive the simplest operational know-how, while those with high capabilities receive more advanced forms, in some cases the R&D process itself. Globalization means that certain forms of technology – mainly operational know-how – diffuses more rapidly than before. It does not, however, mean that the innovation process diffuses more widely or quickly. On the contrary, the more complex elements of productive knowledge are becoming more proprietary. The intensification of competition and the faster spread of information means that innovators are seeking the enforcement of stricter intellectual property rights.

Policy Liberalization: Perhaps the most important recent influence on industrial development in developing countries has been liberalization: on import competition, foreign entry, domestic entry and exit, and capital and labour markets (often accompanied by the privatization and/or reform of public enterprises). Liberalization has been accompanied by a rise in regional trading arrangements, promoting the selective lowering of trade barriers and access to larger markets. Trade liberalization has changed, often radically, the incentive regime in developing countries for industrial investment and technology development. Many effects have been beneficial. Increased competition has forced enterprises to raise efficiency and improve the use of existing technologies. Improved resource allocation between enterprises and activities has promoted growth and investment in many cases.

At the same time, there is no universal, uni-directional link between liberalization and industrial development. Efficient industrialization, and more importantly its upgrading up the value added chain, is a complex phenomenon. It has to draw on many skills and sources of technological learning, in turn calling on factor markets and support institutions. Simply freeing up markets may not help if these markets and institutions are deficient. If firms exposed to international competition are unable to obtain the new skills, technology or finance they need to compete, they simply go under rather than grow dynamically. This is often the case with firms in least developed countries in Sub-Saharan Africa (Lall, 1999.c). At higher levels of capability, rapid liberalization can force firms to leave technologically complex activities or to reduce their technological effort in favour of simply importing technologies. In Latin America, there are many instances of liberalization leading to lower levels of technological effort while upgrading operational technology. This may yield greater operational efficiency but at the cost of longer term dynamism.

New Rules of the Game: The pace and nature of policy change in developing countries are shaped, forced and reinforced by the 'rules of the game' embodied in international trade and investment agreements, procedures and norms. These rules generally strengthen market forces and subject economies to greater international competition and globalization. They open foreign markets further, providing a stronger, clearer and more predictable framework for private enterprise. They are backed by closer surveillance of policies and governance mechanisms. By the same token, they further reduce the ability of governments to mount independent strategies to promote industrial development by intervening in trade and investment flows. This has both benefits and costs, depending on the need for such interventions to promote legitimate economic objectives.

Many of the policies that were effective in raising the competence of leading newly industrializing economies (NIEs) are not acceptable today: the protection of infant industries, local content rules, selectivity on FDI inflows, export and technology subsidies, performance requirements, and so on. In part this is desirable – many of these policies were abused in the past and led to inefficiency. However, when used in the context of coherent strategies by a well-trained and independent bureaucracy, they were able to foster rapid industrial growth and upgrading. The renunciation of some basic tools may therefore be a handicap to latecomers in industrialization.

However, liberalization is now an inexorable force that is unlikely to be reversed. The future policy needs of developing countries have thus to be analyzed in the context of a global economy with free trade, free movements of technology and investment, and ever-tightening communication links. There are still many policy needs and options, and this paper will focus on these.

To sum up, the combination of liberalization, technical change and globalization means that countries are faced with many more opportunities and much more intense competition than before. Productive knowledge moves more quickly across countries in a context in which many previous barriers to trade and information flows are being removed. Its exploitation is undertaken with increasing rapidity within international production systems under the aegis of TNCs, or by competent local enterprises. Cheap labour *per se* is becoming less important to competitiveness except in the simplest entry-level activities. What matters in the new environment is raising *the absorptive base for new technology*. There is much that countries can do to create and enhance this base. The new setting makes this more difficult than before, but it still offers considerable opportunity.

3. Patterns of industrial competitiveness

This section describes patterns of industrial competitiveness in the Asia-Pacific region during 1980-95. The indicator of competitiveness is manufactured exports. For reasons of data availability, the analysis is restricted to two sub-regions: East Asia[2] and South Asia[3]. Nine 'dynamic economies' or NIEs dominate East Asia (accounting for 99.7 per cent of the group's manufactured exports in 1997). We divide these into three sets: the *'mature NIEs'* (Hong Kong, Singapore, the Republic of Korea and Taiwan Province of China), the *'new NIEs'* (Malaysia, Indonesia, Philippines and Thailand), and China. Within South Asia, we single out *India* because it accounts for the bulk (77.5 per cent) of manufactured exports. Given the lack of data on several countries in the region and the small size of many, these ten countries account for over 98 per cent of available manufactured exports from the Asia-Pacific. Of course, while their competitiveness patterns reflects what happens in the region as a whole, their experience does not capture the problems facing smaller or less industrialized economies. We address these problems later.

The pattern of competitiveness is analyzed by dividing manufactured exports by *technological categories*. The reasoning is that export structures reflect underlying patterns of technological competence and specialization. Structures are path dependent and difficult to change. They reflect slow, incremental learning processes, the outcome of resource endowments, skills, technological activity, and the impact of institutions, trade and industrial policies. While structures do change in response to changes in policies and market signals, the accumulation of new capabilities and the entry of foreign direct investment, structural change takes time and effort. Thus, the strengths and weaknesses of export structures can guide industrial policies.

What is a 'desirable' technological structure of manufactured exports? In general terms, while the export structure should reflect initial factor 'endowments' (though it is not clear how endowments should be defined once created endowments like technological capabilities are included), sustaining

[2] This comprises China, Fiji, Hong Kong, Indonesia, Macao, Malaysia, Papua New Guinea, Philippines, Republic of Korea, Singapore, Thailand and Taiwan Province of China (data on transition economies are not available for the period).

[3] This comprises Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka (data on Iran and Afghanistan are not available for the period).

growth and competitiveness with rising incomes requires that it should evolve over time. Different export structures face *different growth prospects*. In general, structures dominated by technology-intensive products have better growth prospects, for the following reasons:

- Activities with the rapid product or process innovation generally enjoy *faster growing demand vis à vis* technologically stagnant activities (as shown earlier in Figure 2).

- Technology-intensive activities are *less vulnerable* to entry by competitors compared to low technology activities where scale, skill and technology requirements are low. A low-technology export structure is a good starting point for a labour-surplus economy, but over time, it can sustain export growth only by taking shares from other low technology exporters. In relatively slow-growing markets, this is possible but difficult. It needs considerable technical effort, high levels of skill and, increasingly, entry into differentiated segments. In fact, it may well be that upgrading into the top segments of technologically simple products (e.g. fashion garments in the clothing industry) is more difficult for developing countries than going up the scale in technologically complex products.

- Technology-intensive activities offer higher learning potential and greater opportunity for the continued application of science to technology. Thus, *ceteris paribus*, they lead to *faster growth in capabilities* and *higher quality capabilities*. This also applies *within* technologies: the assembly of electronic components (within a high-tech activity) is likely to provide more valuable learning than garment assembly (within a low technology activity) because is more skill- and learning-intensive, and has more spillovers. The former calls for more training and uses more sophisticated equipment; as technologies change faster it leads to more rapid and broader based capabilities. The skills and learning generated by low technology activities like garments remain largely confined to the original industry.

- Capabilities in technology-intensive activities are more attuned to technological and market trends, and so are more *flexible* and *responsive* to changing competitive conditions.

- A technology-intensive structure is likely to have *larger spillover benefits* in terms of learning and innovation to other activities and to the national technology system. In fact, there are so many pervasive externalities in learning that it is apt to think of collective rather than firm-specific learning as the main driver of industrial growth.

We divide manufactured exports (205 items of the SITC 3-digit trade classification Rev2) into four technological categories:

- *Resource-based* (RB): such as processed foods and tobacco, simple wood products, refined petroleum products, dyes, leather, precious stones and organic chemicals (67 SITC 3-digit items). These generally have simple and stable technologies (with exceptions like petroleum and some processed foods, with scale and capital intensive processes); competitiveness rests largely on proximity to the resource base.

- *Low technology* (LT): such as textiles, garments, footwear, other leather products, toys, simple metal and plastic products, furniture and glassware (49 items). These are activities with low R&D and skill needs, equipment-embodied technologies and often labour-intensive processes. Competitiveness here rests, at the low end, on labour costs and the mastery of simple technical and organizational skills; at the high end, it requires advanced design and marketing skills and extremely rapid market response.

- *Medium technology* (MT): such as automotive products, industrial chemicals, basic metals, standardized machinery, and simple electrical and electronic products (69 items). These generally involve skill and scale-intensive technologies, and sometimes (as in automobiles or machinery) sophisticated product design. Since they comprise basic intermediates, durables and capital goods, they form the 'heartland' of industrial activity and exports. Competitiveness rests significantly on lengthy learning, organizational and technical skills, and the ability to manage very large-scale and linkage intensive processes.

- *High technology* (HT): a fairly small number of R&D-based products like pharmaceuticals, computers, transistors and other advanced electronics, complex electrical machinery, aircraft and precision instruments (20 items). Competitiveness in core processes involves very advanced skills and massive investments in risky R&D, often with close links to the science/university base. However, many high-tech electronic products have simple, labour-intensive final assembly and testing processes that need basic literacy rather than technical skills.

Table 1 shows the distribution of world trade and rates of growth since 1980. It also shows sub-periods, separating 1995-97 because of the sudden slowdown in trade (that hit East Asia particularly hard and precipitated the financial crisis). The first period, 1980-85, was an even poorer one for world trade, presumably because of the after-effects of the second oil shock. The latter half saw a massive acceleration in trade, a result of resumed growth and liberalization. The first part of the 1990s had fairly robust growth, but not at previous rates.

Table 1: Evolution of World Manufactured Exports by Technological Categories

	Shares (%)				
	1980	1985	199	1995	1997
Primary products	21.4	20.9	13.1	10.2	10.6
Manufactures	76.0	77.8	84.9	87.4	87.7
	Of which				
Resource based	24.1	22.1	20.8	17.8	17.2
Low tech	19.5	18.9	21.1	19.4	18.6
Medium tech	41.8	41.3	37.4	39.7	39.0
High tech	14.6	17.7	20.7	23.2	25.3
	Rates of Growth (% p.a.)				
	1980-85	1985-90	1990-95	1995-97	1980-97
Primary products	0.5	2.5	4.9	4.6	2.8
Manufactures	1.5	14.5	10.8	2.8	8.1
Resource based	-0.2	13.1	7.4	1.1	5.9
Low tech	0.9	17.0	8.9	0.6	7.8
Medium tech	1.2	12.3	12.1	1.9	7.6
High tech	5.5	18.2	13.3	7.3	11.6
Total exports	1.0	12.5	10.2	2.6	7.2

Source: Calculated from UN Comtrade data provided by courtesy of the World Bank.

Note: World exports are calculated as the sum of exports by industrial countries, central and eastern Europe and the developing world. Special transactions (e.g. electric power, works of art, gold bullion, miscellaneous transactions, etc.) are not shown here (that is why primary plus manufactured exports do not add up to 100%).

Primary products had low rates of growth and lost shares steadily; their overall growth, below 3 percent per annum, was only one-third that of manufactures. Within manufacturing, resource based products had the sharpest reduction in share over 1980-97, but low and medium technology products also lost one to three percentage points. High technology products were the real winners, almost doubling their share with an overall growth rate of 12 per cent.[4] Not only was their growth higher than for other groups in every sub-period, they also maintained growth best in 1995-97 (despite a sharp fall in the prices of semiconductors, a major high-tech product). On current trends, they will become the largest single group in trade in the medium term.

Medium technology products dominate manufactured trade, with around 40 percent of the total over the period. There is practically no difference in overall growth rates between low and medium technology products. Medium technology products grew slower than low technology ones during 1985-95 and faster in other sub-periods. It is possible, however, that the recent slowdown in low technology export growth signifies a maturing of the relocation that first drove their growth. A more detailed breakdown between textile and footwear products (the main locus of relocation) and other low technology products like simple metal products (not shown here) suggests that this may be so. The former group slows down more far more than the latter. While, we have to wait for more data before drawing any conclusions, there are important policy implications if this is so – the garment and footwear industry has been a major engine of industrial growth and competitiveness in the Asia-Pacific region.

What was the role of developing countries in world trade? Table 2 shows the growth and shares of manufactured exports for industrialized and developing countries. Developing countries had higher growth rates over 1980-97 in each category, to be expected given their smaller initial base. What is surprising is that their lead over industrial countries *rose with technological complexity*. While they clearly had an advantage in LT products, accounting for over one-third of world exports, their next largest share was in HT products and here their growth rate was much faster. Their lowest share was in MT, reflecting the complex and lengthy learning involved in these activities.

Table 2: Growth and Shares of Manufactured Exports by Technological Categories, 1980-97 (%)

	Growth Rates (% p.a.)				Developing Country Shares (%)		
	World	Industrialized Countries	Developing Countries	Difference: Developing-Industrialized	1980	1997	Change in share
All exports	7.2	6.7	8.5	1.8	22.5	27.6	5.1
RB	5.9	5.3	8.1	2.8	18.0	25.5	7.5
LT	7.8	6.1	12.4	6.3	17.7	36.5	18.8
MT	7.6	6.8	16.4	9.6	4.3	16.2	11.9
HT	11.6	9.9	21.2	11.3	7.0	28.1	21.1
Total mfrs.	12.2	7.0	13.5	6.5	10.6	24.6	14.0

Source: As previous table.

Note: Industrialised countries include Israel. Developing countries include the mature Tigers, Turkey and South Africa.

By value, the developing world's HT exports in 1997 were $287 billion, larger than other categories: RB ($177 billion), LT ($274 billion) and MT ($256 billion). Not only do these figures suggest enormous technological upgrading, they suggest growing advantages in R&D intensive activities. This is somewhat misleading. It does not mean that the developing world has leapfrogged to the technological frontier, and now has a solid competitive base in high technology activities. There are two important caveats to what the figures show. First, much of HT exports are a statistical artefact, in that they show (simple labour-intensive) final assembly of electronic components. Most of the technology intensive work retained in industrial countries, and local physical and technological content is often very low. In effect, therefore, LT processes drive HT exports. Second, manufactured

[4] The share of HT products is, as may be expected, considerably larger within the group of fastest growing exports. Thus, they account for 47% of the 1995 value of the 50 fastest growing manufactured exports in 1985-95 (the 50 products themselves account for 40% of all manufactured exports).

export activity is highly concentrated. The data reflect the success of a small number of countries, and conceal the weak performance of the great majority of others.

However, the growth of HT exports by developing countries is not based entirely on simple assembly by TNCs. A significant part is based on the accumulation of domestic technological and other capabilities, with large local content and R&D inputs. This applies even more to MT exports, which are less amenable to the relocation of final assembly in low wage areas. Most developing countries with advanced domestic capabilities in high technology products are in the Asia-Pacific; their strategies to develop such capabilities are relevant to this analysis and we return to them later. Moreover, even 'simple' assembly of imported components by TNCs contributes to technological deepening in host countries. While the process of technology development has been slower and shallower than when governments used industrial policy to compress and accelerate local technological learning, it does occur. Again, there are good examples of this process in the region.

Table 3: Shares of regions in developing world exports by major categories

	1985	1990	1995
Total manufactures			
East Asia	66.5%	74.0%	75.3%
South Asia	5.2%	5.0%	3.7%
LAC	19.4%	13.9%	15.2%
MENA	4.9%	4.6%	3.6%
SSA 1	1.2%	0.8%	0.5%
SSA 2	4.0%	2.5%	2.2%
Resource based			
East Asia	44.6%	51.7%	53.3%
South Asia	5.0%	5.6%	5.3%
LAC	33.8%	25.3%	27.8%
MENA	10.1%	12.3%	7.5%
SSA 1	2.3%	1.8%	1.4%
SSA 2	6.6%	5.1%	6.1%
Low technology			
East Asia	76.9%	78.4%	77.3%
South Asia	8.9%	8.7%	7.3%
LAC	10.0%	8.0%	9.4%
MENA	2.2%	3.0%	4.6%
SSA 1	0.7%	0.7%	0.6%
SSA 2	2.1%	1.9%	1.5%
Medium technology			
East Asia	72.3%	73.9%	73.3%
South Asia	2.3%	2.2%	1.6%
LAC	18.7%	18.8%	20.2%
MENA	3.1%	2.7%	2.8%
SSA 1	0.8%	0.6%	0.3%
SSA 2	3.6%	2.3%	2.1%
High technology			
East Asia	90.1%	94.2%	90.5%
South Asia	1.2%	1.1%	0.6%
LAC	5.8%	4.1%	8.0%
MENA	0.7%	0.3%	0.6%
SSA 1	0.2%	0.1%	0.0%
SSA 2	2.2%	0.4%	0.3%

Source: Calculated from UN Comtrade database.
Note: LAC stands for Latin America and the Caribbean, MENA for North Africa and the Middle East (including Turkey but excluding Israel, which is counted as part of the industrial world). SSA stands for Sub-Saharan Africa; SSA 1 excludes South Africa, SSA 2 includes it.

What is the role of Asia-Pacific in the developing world? Table 3 shows the regional breakdown of manufactured exports by technological categories for six regions (Sub-Saharan Africa is shown with and without South Africa, the largest exporter and a clear 'outlier'). East Asia not only dominates all categories, its dominance has risen over time. By 1995, it accounts for three-quarters of total manufactured exports by developing countries. Its share is lowest in the RB category; nevertheless, even here its share is rising, reaching over 53 per cent by 1995. Its largest share is in HT products, where it accounts for 90 per cent. However, this share has fallen from 94 per cent in 1990, due entirely to the rapid growth of Latin America. This has been driven entirely by Mexico, where NAFTA and other tariff privileges given by the USA to its border *maquiladoras* have led to a massive increase in electronics exports (with low local content).

These trading arrangements have also boosted Mexican exports to the US market of automotive and other engineering products (under MT exports) and clothing (under LT exports).[5] In many products across the categories, therefore, Mexico is emerging as the largest competitive threat to Asia-Pacific in the North American market. The rest of LAC offers little direct competition to East Asia. In low technology products, the other major competitors are South Asia and MENA, where Turkey, Morocco and Tunisia are important exporters of garments to the EU. Again, their success is based partly on proximity and partly on privileged market access – once such access is abolished (say, with the demise of the MFA), they are likely to lose to East and South Asia.

South Asia does badly in comparison with East Asia (though less so relative to other regions). Its share of developing world exports falls over time, in total and in all categories. The percentage point loss is small (under 1 per cent) in each category except for LT products, where it loses 1.4 per cent.

[5] Mexico is the largest, and most dynamic, manufactured exporter in Latin America. In 1997, its exports accounted for 68% of HT, 62% of MT, and 54% of LT exports by the Latin American and Caribbean region.

However, it is in this category that it has the largest export share; it shares in high and medium technology products are between 1 and 2 per cent. The high weight of LT and RB products suggests serious structural weaknesses, particularly marked for India where, despite some liberalization and a deep and diverse industrial base, export upgrading has been weak (Lall, 1999.a).

Let us now look at performance at the country level. Table 4 shows the values and growth rates of manufactured exports for ten Asia -Pacific countries, three LAC economies, Turkey and South Africa, as well as for the regions (including industrialized countries and the world). Of the many points of interest in this table, we note the following:

- Developing countries have been the engine of growth through the period. Their importance is

Table 4: Manufactured exports by leading developing countries (US$ million)

	Values ($ million)					Rates of growth (% per annum)					
	1980	1985	1990	1995	1997	1980-85	1985-90	1990-95	1995-97	1980-97	1985-95
Asia-Pacific											
Hong Kong	13,239.9	15,979.5	27,834.3	28,333.0	25,876.9	3.8%	11.7%	0.4%	-4.4%	4.0%	5.9%
Singapore	15,031.9	19,014.0	48,876.8	109,900.5	116,179.7	4.8%	20.8%	17.6%	2.8%	12.8%	19.2%
Korea	16,314.5	29,025.0	62,409.1	119,138.4	126,053.3	12.2%	16.5%	13.8%	2.9%	12.8%	15.2%
Taiwan	18,782.4	28,948.8	63,487.2	104,464.0	108,849.1	9.0%	17.0%	10.5%	2.1%	10.9%	13.7%
Malaysia	6,121.3	8,626.5	21,772.0	64,822.9	68,995.2	7.1%	20.3%	24.4%	3.2%	15.3%	22.3%
Indonesia	4,251.4	3,856.4	11,900.8	29,018.5	29,240.6	-1.9%	25.3%	19.5%	0.4%	12.0%	22.4%
Philippines	3,995.6	3,428.7	5,662.7	13,704.2	21,823.3	-3.0%	10.6%	19.3%	26.2%	10.5%	14.9%
Thailand	2,258.4	3,657.6	17,255.0	46,129.4	47,190.4	10.1%	36.4%	21.7%	1.1%	19.6%	28.8%
China	N/A	6,049.2	48,043.4	132,784.0	164,209.3	N/A	51.4%	22.5%	11.2%	N/A	36.2%
India	4,901.9	6,208.9	13,986.6	25,021.0	27,178.4	4.8%	17.6%	12.3%	4.2%	10.6%	15.0%
Other NIEs											
Argentina	3,387.2	3,702.9	6,609.7	11,355.4	13,865.2	1.8%	12.3%	11.4%	10.5%	8.6%	11.9%
Brazil	14,855.8	17,616.8	23,404.6	35,327.3	38,079.4	4.4%	5.8%	8.6%	3.8%	6.1%	7.2%
Mexico	5,867.5	8,336.2	13,216.3	64,822.3	92,645.6	9.2%	9.7%	37.4%	19.6%	18.8%	22.8%
Turkey	1,671.5	5,790.4	9,803.4	18,475.4	22,311.8	36.4%	11.1%	13.5%	9.9%	17.6%	12.3%
South Africa	6,490.4	4,963.7	6,842.0	16,095.7	15,907.7	-5.2%	6.6%	18.7%	-0.6%	5.4%	12.5%
Total above 15	117,169.6	165,204.5	381,103.8	819,391.9	918,405.8	7.1%	18.2%	16.5%	5.9%	12.9%	17.4%
Share of LDC total	*102.1%*	*91.5%*	*90.9%*	*85.8%*	*92.3%*						
Regions											
East Asia	80,780.3	120,084.2	309,971.9	719,342.0	710,451.7	8.3%	20.9%	18.3%	-0.6%	13.6%	19.6%
South Asia	5,930.0	9,444.3	21,020.0	35,399.8	35,078.7	9.8%	17.4%	11.0%	-0.5%	11.0%	14.1%
LAC	10,269.2	35,042.5	58,428.5	145,134.0	181,516.1	27.8%	10.8%	20.0%	11.8%	18.4%	15.3%
MENA	7,634.7	8,823.7	19,307.5	34,299.4	48,387.0	2.9%	17.0%	12.2%	18.8%	11.5%	14.5%
SSA 1	3,625.6	2,222.8	3,540.2	4,841.4	3,616.7	-9.3%	9.8%	6.5%	-13.6%	0.0%	8.1%
SSA 2	10,116.0	7,186.5	10,382.2	20,937.1	19,524.4	-6.6%	7.6%	15.1%	-3.4%	3.9%	11.3%
Developing countries	114,730.3	180,581.2	419,110.2	955,112.3	994,957.9	9.5%	18.3%	17.9%	2.1%	13.5%	18.1%
Industrial countries	967,387.4	984,928.8	1,875,637.9	2,877,696.9	3,054,139.6	0.4%	13.7%	8.9%	3.0%	7.0%	11.3%
World	1,082,117.7	1,165,510.0	2,294,748.1	3,832,809.2	4,049,097.5	1.5%	14.5%	10.8%	2.8%	8.1%	12.6%

Source: Calculated from UN Comtrade database.

Notes: 'Developing countries' include all above regions but not the Central Asia or the transition economies of Asia-Pacific, on which data are not available for the period. Industrial countries include Central and East Europe but not the Soviet Union or other transition economies, again for data reasons.

Data for 1980 are not available for Brazil, Chile, Mexico, Turkey and Egypt. The figures shown are for 1981, explaining why the 1980 total for the top 15 countries exceeds the total for developing world for that year (derived from regional totals). Rates of growth for these countries (for 1980-85and 1980-97) are adjusted for the shorter time period; however, the regional growth rates for these periods reflect the low base since I could not account for the missing countries for that year. That is why LAC shows very high growth rates for 1980-85 and 1980-97.

Singapore's figures include re-exports while Hong Kong's exclude it. This causes some double counting for East Asian exports, particularly for Southeast Asia. However, Singapore's own manufactured exports are substantial, accounting for around 60% of its total exports.

greatest in 1990-95, when industrial countries' exports decelerate significantly and the rising share of developing countries allow them to drive overall growth more than before. However, during the slackening of 1995-97, the industrial countries grow slightly faster.

- Exports are enormously concentrated in the developing world. The leading 15 countries account for around 90 per cent of the total, with no sign of concentration declining.[6] The leading five exporters are all East Asian, accounting for around 60 per cent of the total through the period.

- China emerges since 1990 as the largest exporter by far in the developing world, overtaking the mature NIEs. Its growth rate over 1985-95, at 36 per cent per annum, is the highest in the group and probably the highest of all sizeable exporters in the world. A very large part of its exports come from assembly operations in its Special Economic Zones, mainly from joint ventures operated by firms from the mature NIEs, in particular Hong Kong.

- Of the mature NIEs, Hong Kong has the weakest export performance, compensated by offshore assembly by its enterprises in China and elsewhere. Its specialization in low technology products means that its industrial sector cannot compete with rising wage and land costs. This is in contrast to Singapore, which has higher wages but has been able to enter high value added industrial activities. Thus, Singaporean manufactured exports do better than the other mature NIEs over 1985-95. However, all three maintain double-digit growth rates, despite large export bases, rising wages and growing maturity.

- Of the new NIEs, Thailand has the best overall performance. However, along with Indonesia, it was badly hit by the 1995-97 slowdown. Philippines emerges in recent years as the most dynamic exporter in recent years, driven by an explosion of semiconductor exports under the aegis of TNCs (Lall, 1999.b).

- India has a respectable growth rate over the period, particularly in 1985-95. However, much of the growth is in the first five years; performance flags in the 1990s, despite liberalization in the early part of the decade, and it under-performs most other large exporters in the region.

Let us now consider the technological structure of exports. Table 5 gives the distribution over the technological categories by these countries and regions in 1985 and 1995; an annex table gives a more detailed breakdown by sub-categories.

At the regional level, East Asia has the highest share of HT products, exceeding not just other developing regions but also the industrial countries; over one-thirds of its exports are high-tech and their share more than doubles over the decade. Within this category, electronic and electrical products dominate (annex); other HT products are relatively small. Low technology products are next. They lose share over the period, with the largest loss coming in textile, clothing and footwear products. These 'fashion cluster' products also grow relatively slowly in world trade as a whole, perhaps signifying that the massive relocation from high to low wage countries that earlier drove their growth is reaching maturity. If so, it would have important implications for countries in the region, in East and South Asia, that depend heavily on them for the export earnings and growth.

South Asia is highly dependent on low technology (overwhelmingly textile and clothing) products, and raises its dependence on them over time, largely at the cost of RB products. Its share of HT products is relatively low, and rises marginally because of Indian pharmaceutical exports. Its MT exports also largely reflect Indian chemical and other process industry exports. Of the other regions, only LAC has a significant showing in HT, due primarily to Mexican *maquiladoras*. However, it also does well in MT products, a result of the widespread restructuring of automotive and process industries (e.g. vegetable oil and petroleum products) consequent upon trade and FDI liberalization. Latin America is the largest exporter of auto products (including components) in the developing world,

[6] The rise in concentration over 1990-95 may be misleading because the developing world total reflects missing data from a number of smaller exporters, particularly in South Asia and Africa.

with $25.4 billion in 1997 (of which $17.4 billion comes from Mexico, $4.4 billion from Brazil and $2.6 billion from Argentina). This compares with $22 billion for East Asia (Korea accounts for $12.3 billion and Taiwan Province for $4.5 billion). In Mexico, this is aimed at the US market, in Brazil and Argentina at each other (the MERCOSUR) and some at the OECD. Note that most MT exports in Latin America emanate from well-established import-substituting activities with complex processes, where building competitiveness has required long learning periods. Many are under TNC control, but large domestic conglomerates also own several, particularly in the oil and food processing sectors.

Table 5: Percentage distribution of manufactured exports, 1985 & 1995

	1985				1995			
	RB	LT	MT	HT	RB	LT	MT	HT
Hong Kong	3.2%	63.0%	19.1%	14.8%	6.0%	52.0%	15.1%	27.0%
Singapore	43.5%	8.6%	23.4%	24.5%	13.9%	7.0%	19.3%	59.8%
Korea	8.6%	41.4%	37.2%	12.8%	10.9%	20.3%	39.0%	29.8%
Taiwan	9.9%	52.9%	26.0%	25.9%	5.4%	30.0%	27.5%	37.2%
Malaysia	53.7%	8.0%	11.4%	26.9%	18.0%	11.2%	19.9%	51.0%
Philippines	39.6%	17.1%	6.4%	36.9%	9.5%	13.1%	8.6%	68.9%
Thailand	37.9%	35.4%	22.0%	4.7%	19.3%	25.3%	20.5%	34.8%
Indonesia	75.2%	15.5%	6.4%	3.0%	44.1%	30.3%	16.0%	9.5%
China	38.8%	43.7%	12.2%	5.2%	10.9%	51.8%	19.8%	17.4%
India	40.6%	45.3%	10.1%	4.1%	30.2%	48.7%	14.6%	6.6%
Argentina	60.2%	16.3%	19.0%	4.4%	41.8%	17.4%	36.5%	4.4%
Brazil	44.0%	21.3%	29.8%	4.9%	38.0%	16.7%	38.6%	6.6%
Mexico	21.1%	13.2%	55.4%	9.0%	7.3%	19.8%	45.2%	27.7%
Turkey	21.8%	53.1%	23.5%	1.6%	16.9%	56.9%	21.4%	4.8%
Egypt	62.0%	35.2%	1.7%	1.1%	50.3%	39.3%	8.1%	2.3%
South Africa	53.4%	16.4%	21.2%	9.0%	49.7%	16.4%	30.0%	3.9%
East Asia	23.0%	38.3%	23.0%	15.7%	11.9%	29.3%	25.3%	33.4%
South Asia	32.3%	55.8%	9.2%	2.8%	25.1%	58.7%	12.1%	4.2%
LAC	59.3%	16.9%	20.3%	3.6%	32.2%	18.4%	36.1%	13.3%
MENA	70.3%	14.6%	13.4%	1.7%	36.7%	37.9%	20.9%	4.5%
SSA 1	64.7%	19.3%	14.5%	1.6%	40.8%	44.2%	13.0%	1.9%
SSA 2	56.9%	17.3%	19.1%	6.7%	48.2%	22.2%	24.4%	5.2%
Developing countries	34.1%	32.9%	21.0%	12.1%	17.6%	29.9%	27.2%	25.3%
Industrial countries	19.9%	16.4%	45.0%	18.7%	17.9%	15.9%	43.8%	22.4%
World	22.1%	18.9%	41.3%	17.7%	17.8%	19.4%	39.7%	23.2%

At the country level, the highest technology-based export structure of the mature NIEs is in Singapore, followed by Taiwan. Korea has a stronger base in MT activities, reflecting its heavier industry base. Hong Kong remains specialized in low technology activities, a result of its *laissez faire* policies towards industrial deepening (Lall, 1996). Of the new NIEs, Philippines now has nearly 70 per cent of manufactured exports coming from high-tech activities, followed by Malaysia with 51 per cent. At the other end, Indonesia remains primarily in RB and LT activities. China is also mainly a low technology exporter, but is raising sharply the share coming from HT products.

These figures are not, as they stand, accurate representations of national technological capabilities. As noted above, HT exports may simply represent low-level assembly activity by TNCs, with few local linkages and no domestic technological inputs. To gauge how much *domestic* capabilities are involved, we need to look at such things as local physical and equipment content, design and R&D, skill inputs and the role of local companies. It is not possible to get detailed data on all this, but qualitative evidence and data on R&D and skills (below) suggest that the ranking of industrial capabilities in East Asia would look something like this (Lall, 1996):

- Korea
- Taiwan
- Singapore

- Hong Kong
- Malaysia
- Thailand
- Philippines
- Indonesia

The ranking may change by individual activities but in overall terms there is no doubt that Korea has built up the largest, more diverse and deepest technological capabilities not just in the region but also in the developing world. It is followed closely by Taiwan, with a more flexible and technology oriented structure but less heavy industry. Singapore remains heavily dependent on TNCs for innovation, but within the international production framework it has induced TNCs to deepen their technological activity and undertake the most advanced processes. Malaysia is trying to do the same, but still has some way to go. Thailand has advanced local companies in low and medium technology activities, but lags in deepening high-tech activities. Philippines has more advanced skills but its production structure is still relatively shallow. Indonesia has a very recent and shallow technology base.

To conclude this section, there are many patterns of competitiveness in the Asia-Pacific region. The East Asian NIEs are the most dynamic in the world, not just in terms of export growth but also of moving into dynamic and technologically advanced activities. There is no reason to expect that the recent financial crisis will affect this position. While some industries have been damaged during the crisis, the productive fabric remains intact and the capabilities that drove earlier success are still in place. However, there differences between them with respect to the strategies followed. Broadly speaking, there have been four types of strategies.

- ✓ The *first*, represented by Korea and Taiwan Province, is based upon domestic skill and technology accumulation in a range of complex industries approaching or surpassing that in the industrial world. This has been driven by extensive industrial policy, and has allowed them to combine rapid export growth with considerable diversification and deepening of their competitive base. Local content (physical and intellectual) is very high. Local firms lead exports, and many are now independent global players. FDI has been tightly restricted, as in Korea, or allowed in on very controlled terms, as in Taiwan. Their manufactured exports have the greatest 'technological depth', and their industrial sectors the most advanced technological and innovative capabilities, in the developing world.

- ✓ The *second* pattern is that of countries whose export success is driven by FDI, but that have used strong industrial policy (with skill and infrastructure upgrading) and FDI targeting to up the technological ladder. The prime example is Singapore, but other countries like Malaysia are trying to emulate its example. This strategy has resulted in a highly advanced export structure with appropriate skills and management capabilities, but relatively limited local innovation, though this is rising now under strong government support.

- ✓ The *third* pattern also involves MNC-led exports, but here FDI strategy is relatively passive and industrial policy weak. Success depends on using cheap and trainable labour, with welcoming FDI policies, good export processing facilities, a favourable location and sometimes privileged access to major markets. Local physical and technological inputs tend to be low, and upgrading to more value added products slow. There is often very limited linkage between export-oriented TNCs and local firms. Skill upgrading and technological activity are lagging. Where sunk costs are low, export-oriented facilities relocate when wages rise. Where they are high and TNCs invest in local skill upgrading, the facilities tend to stay. However their growth is constrained by skill and technology shortages as processes grow more complex. Among the leading exporters, the new Tigers and the export processing zones of China exemplify this pattern. In the new Tigers, exports have moved from low into high technology products because of the timing of the electronics assembly boom, but not in more recent exporters (Sri Lanka or Bangladesh in the Asia-Pacific region). Specialization in HT has led the new Tigers to develop greater skills, and more durable export bases, than newer entrants. However, capabilities remain mainly at the production level; technological content is much lower than in the mature Tigers.

✓ The *fourth* pattern is in economies whose industries developed mainly under import substitution — India, China and Pakistan in the region – that are now liberalizing on trade and FDI. Excluding exports from EPZs, their exports reflect capabilities built earlier (pharmaceuticals and machinery in India and China). However, upgrading is generally not guided by coherent and comprehensive policies that characterize the Tigers. In South Asia, technological content remains low. Indian software exports are clearly an exception, but these do not show up in our data and do not affect the conclusion on product exports. Pakistani manufactured exports are even more heavily biased towards simple textile and clothing products. Its lack of a diverse industrial base, coupled with the failure to attract export-oriented FDI, has held back upgrading even more than in India. The technological base in all these large countries is narrower and less dynamic than in the mature Tigers. Future evolution of competitiveness depends crucially on their ability to mount a mixture of the first and second patterns above.

4. Role of industry in the new millennium

While it is evident that services, particularly modern services based on information technology, will provide a significant source of growth in the future, it is also evident that manufacturing will continue to play a major role. This role will be more important in developing countries, with the possible exception of those that are already heavily industrialized or have special competitive advantages in providing services for export. It is easy to conceive, for instance, that Hong Kong or Singapore will shift out of manufacturing into financial, marketing, transport, design and other services, using their strategic location to serve neighbouring economies. Hong Kong has already done this to a large extent; Singapore is retaining a large and growing manufacturing sector while developing advanced service activities. For other economies, particularly those that have not gone through a broad-based industrialization process, there will be a large role of manufacturing.

There are several reasons to expect this. Manufacturing remains the main agent for structural transformation for economies emerging from low-productivity agricultural and simple service activities (Chenery *et al*, 1986). It allows for a much greater, broader and more rapid application of science and technology than traditional activities. It creates new skills, not just in the productive process but also in management, organization and supporting activities. It becomes a major source of employment and seedbed for entrepreneurship. It changes attitudes and perceptions, particularly if activities are export-oriented and attract FDI. It provides new, more dynamic and diverse, sources of comparative advantage in international trade; if manufacturing is upgraded, these sources are compatible with rising incomes and wages. While high value added services will certainly play an increasing role, few of them will provide sources of export earnings (few countries can hope to replicate the success of Indian software exports but many more can hope to grow on the basis of manufactured exports). More important is the fact that many new services are *linked intimately* to manufacturing, serving its needs, growing directly out of manufacturing or using the skills first developed under manufacturing.[7] Without a phase of intense industrial development, it is difficult to envisage typical developing countries leapfrogging in terms of capability development to the frontiers of modern exportable services.

Thus, manufacturing will continue to be an important and powerful engine for growth and exports. However, the changing context means that some objectives of industrialization may change. In the early days of development planning, many countries saw its role as providing a large range of products to substitute for imports. They also saw manufacturing as a means of adding value to local natural resources and diversifying sources of exports. SMEs were seen as providers of employment

[7] Indian software capabilities in Bangalore, the pioneer and largest centre of software exports, were originally developed to serve three large electronic manufacturing facilities there, linked to public sector telecommunications, machine tools and defence industries.

and entrepreneurial skills. The rise of domestic firms was often seen as a counter to the traditional dominance of foreign companies.

Many of these objectives remain valid in the new environment. However, in a setting of rapid technical change, free trade and liberal movements of capital and technology, the *priorities*, and *means* of achieving them, have to change. Manufacturing now has to meet the needs of economic *competitiveness* in an open globalizing world, where flexibility, rapid response and competence in using state-of-the-art technologies and logistics are the determinants of growth and survival. It is by enhancing competitiveness – directly within industrial activities and indirectly by making the economic structure more flexible, progressive and outward oriented – that industrial activity can contribute most to growth and well being. Unlike the old paradigm of industrial development, where competitiveness and constant upgrading were not important in comparison to just building industrial capacity, today it is *capability* rather than capacity that matters. This provides the 'bread and butter' to fund all other economic and social objectives.

Without the ability to compete with rising incomes and employment, no economy can over the long term to meet such objectives as poverty alleviation, human development and social wellbeing. In the short term, there may appear to be conflicts and tradeoffs between growth, distribution and competitiveness – in the long-term there are none.

The contribution industry can make to a competitive, flexible and dynamic economy depends on:

- An incentive regime that combines openness to trade, capital and technology flows with good corporate governance and stability. This does not mean an immediate move to free markets. Institutions and rules have to be developed gradually and with care. Free trade remains a long-term objective, but it should be achieved gradually to avoid disruption and allow for deepening into more advanced activities. The disruptive powers of free financial flows has been so amply demonstrated that the need for better governance, information and care in opening capital markets does not need to be argued here.

- Greater openness to FDI and more active participation in international production networks. Again, this does not mean a passive open-door attitude to international investment flows. Open, stable and non-discriminatory policies have to be combined with proactive targeting and attraction strategies. This has to be supported by internal regimes that offer low transaction costs (related to entry, exit, expansion, hiring and firing, capital market access and so on).

- The critical need to promote technological upgrading and deepening in industry, in local as well as foreign enterprises. Technology development faces a number of difficulties and market or institutional failures; as argued below, therefore, it calls for policy support. In the new industrial paradigm, the instruments of support have to reflect the need for openness to capital and technology flows and the prime role of market forces.

- A skill base that can support industrial competitiveness and upgrading. Manufacturing itself creates new skills, but it needs a base of formally trained employees to absorb skills and keep up with new knowledge. As economies grow more complex, the need is for more advanced technical, scientific, managerial and professional skills.

- Modern infrastructure (telecommunications and Internet links) and advanced logistics.

In sum, the thrust of future industry has to be competitiveness based on open and transparent policy regimes, participation in globalized activity, advanced technological capabilities and skills, and interaction with new state-of-the-art services and infrastructure. These define the thrust of future industrial development: let us now look at the strategic policy needs.

5. Future industrial strategies

We noted at the start four critical areas of policy for industrial success: *technological activity, skill formation, FDI attraction* and the *incentive regime*. This section describes what countries in the Asia-Pacific region are doing under these headings (with some comparisons as before), and what the needs are for the different groups of countries.

5.1 Technological activity

Technological activity in developing countries consists less of R&D for 'innovation' (creating new technologies) than of incremental learning, adaptive and improvement. Such activity is diffuse in nature and occurs at all levels of industrial activity – procurement, design, production and distribution. Its intensity and effectiveness determine industrial competitiveness and growth, since the same technology can be (and is) used at widely different levels of efficiency in different firms and countries. Unfortunately, we cannot measure such diffuse technological activity. What we can measure is formal R&D, as a rough indicator of technological effort.

In fact, it is also useful to look at R&D for its own sake in newly industrializing countries, since it becomes an important input into industrial competitiveness with growing maturity. As countries import more complex technologies, R&D is necessary to absorb them and adapt them to local conditions. R&D is the best way to monitor global technological developments and select those that are relevant to future competitive needs. It lowers the cost of technology transfer and captures more spillovers created by the operation of TNCs. A growing R&D base permits better and faster technology diffusion within the economy and facilitates greater use of local resources. It makes it feasible and attractive for TNCs to locate their own design and development work there. Most importantly, it permits the industrial sector greater flexibility and diversification, and allows it greater autonomy. While it is possible to grow rapidly without investing in local technological effort, this works best at low levels of industrial development. To get into higher value-added activities a country has to develop its own R&D capabilities. As we see below, many fast growing economies in the Asian Pacific region face exactly this problem: they are at a stage when they *have* to deepen their technological base.

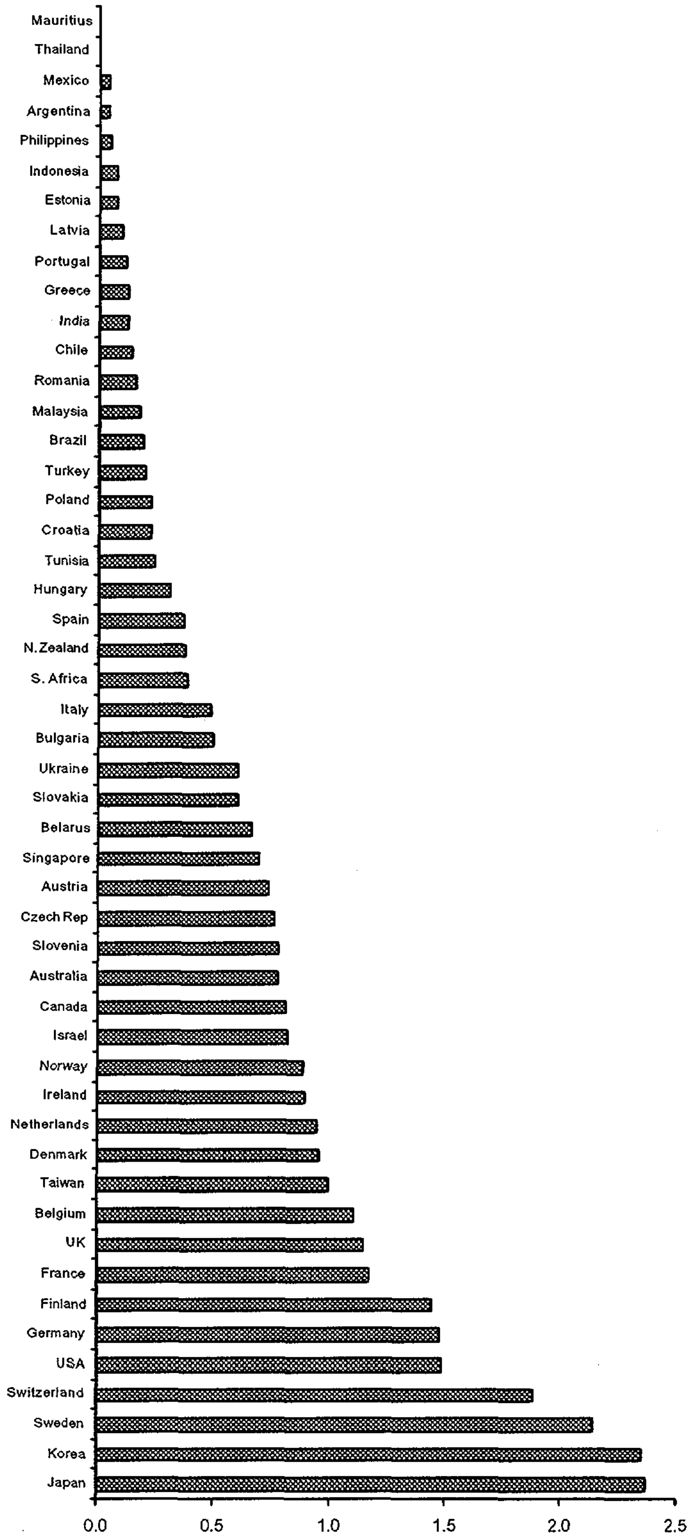
Table 6 shows R&D spending and technical manpower (scientists and engineers in R&D) by region and groups in the developing world. Interestingly, the patterns broadly reflect the technological depth of exports as analyzed earlier. Productive enterprise financed R&D as a share of GNP – perhaps the best indicator of *technologically useful* R&D – in the mature Tigers is nearly 400 times higher than in Sub-Saharan Africa, and around 10 times higher than in the new Tigers and Latin America. Asia

Table 6: R&D Propensities and manpower in major country groups (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
Mature Tigers (d)	2,121	189,212	1.50	50.1	36.6	51.2	45.8	0.768	0.751
New Tigers (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 author from UNESCO *Statistical Yearbook 1997*. Regional propensities for R&D spending are *simple* averages.
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.

Figure 1: R&D by productive enterprises as % GNP (Top 50 countries)



accounts for 86 percent of R&D scientists and engineers in the developing world, Sub-Saharan Africa for 0.3 percent, and Latin America for 10 percent. The proportion of enterprise financed R&D in total R&D spending is highest in the mature Tigers, followed by the new Tigers, and lowest in Sub-Saharan Africa. Latin America and South Asia are close together with below 10 percent of R&D financed by productive enterprises.

However, these averages conceal large variations at the national level. Figure 1 shows productive enterprise financed R&D as a percentage of GNP for the 50 leading countries that provide data to UNESCO. Somewhat surprisingly, Korea turns out to be one of the leaders. Its ratio is the highest, not only in the developing world, but also, apart from Japan, in the world as a whole. Taiwan Province comes next in the developing world, with a lower ratio than the UK but more than the Netherlands or Italy. Singapore comes next, much lower down the world scale; note that its high dependence on FDI has not held back its government from mounting strong technology policies, with a substantial part of private sector R&D coming from foreign affiliates. Hong Kong does not publish R&D data, but reports suggest that total national R&D is only 0.5% of GNP and enterprise financed R&D is a very small proportion of this; this would put it near the bottom of the whole group of 50 countries. The other three mature NIEs are, however, in a class apart from the rest of the developing world.

Of the new NIEs, Malaysia leads while Thailand comes in last, even lower than Indonesia. This reveals one important weakness in Thai competitiveness, the shallowness of high technology export activity (Lall, 1998.c). India falls between Malaysia and Indonesia, ranking seventh in the developing world.

TNCs account for substantial portions of technological effort in Singapore, Malaysia, Brazil and Mexico. Interestingly, the latter two, while attracting most US TNC affiliate R&D, are poor performers in overall terms. In Korea and Taiwan, R&D by local firms takes precedence, driven by strategies to restrict FDI inflows and reverse the passive reliance on foreign technologies that marks most countries (on Korean technology policies see Box 1).

Box 1: Technology Policies in Korea

The Korean government supported technological effort directly in several ways. It stimulated private R&D directly by providing incentives and other forms of assistance. *Direct incentives* 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 commercialize 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.

The Korean government also gave various subsidies for R&D spending:

- The Designated R&D Programme (started in 1982) supported private firms undertaking research in core strategic technology development projects in the industrial area approved by the Ministry of Science and Technology. It funded up to 50 per cent of R&D costs of large firms and up to 80 per cent for SMEs. Between 1982 and 1993, this Programme funded 2,412 projects, which employed around 25,000 researchers at a total cost of around $2 billion, of which the government contributed 58 per cent. It resulted in 1,384 patent applications, 675 commercialized products and $33 million of direct exports of know-how. Its indirect contribution in terms of training researchers and enhancing enterprise research capabilities was much larger. The value of grants under the Programme in 1994 was $186 million, of which 42 per cent was directed at high technology products like new speciality chemicals.
- The Industrial Technology Development Programme, started in 1987, subsidized up to two-thirds of the R&D costs of joint projects of national interest (National Research Projects) between private firms and research institutes. Between 1987 and 1993 this Programme sponsored 1,426 projects at the cost of $1.1 billion, of which the subsidy element from the government was 41 per cent. In 1994, the Programme gave grants of $180 million (with 31 per cent going to high technology products), a significant increase from $69 million in 1990..
- The Highly Advanced National Project (HAN) was launched in 1992 to support two activities. The first was the development of specific high-technology products in which Korea could catch up with advanced industrial countries in a decade or two (Product Technology Development Project). The second was the development of 'core' technologies considered essential for the economy in which Korea wanted to achieve an independent innovative base (Fundamental Technology Development Project). till 1995, 11 HAN projects were selected, for which the government provided $350 million of subsidies during 1992-94. In this brief period, HAN resulted in 1,634 patent applications and 298 registrations.

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.

Given this great divergence of performance and the wealth of experience in the leading NIEs, what can we say about policies to promote technological effort in the new environment?

First, many of the traditional policies used to foster industrialization and technology development are no longer relevant. Thus, import protection, restricting FDI or inflows of technology (by equipment imports and licensing), subsidizing credit, and imposing local content rules are ruled out under new WTO rules or regarded as inefficient by governments. Other policies are needed.

Second, the setting for technology policy is different. Apart from the more rapid pace of technology development, there are more diverse avenues for obtaining mature technologies while access to valuable new technologies is often restricted to direct investment by TNCs. At the same time, participation in a global production chain under TNC aegis is a very effective way of obtaining the latest know-how, but it is insufficient to ensure local technology development. Governments still have to promote this development. They can induce TNCs to upgrade the technologies they bring in and the activities they allocate to their affiliates (below), but they also have to raise technology levels within local enterprises, particularly SMEs.

Third, the most effective and permissible tools for promoting local technology development are as follows:

- Instead of setting technological priorities in the usual top-down process, involving all the major actors (industry, universities, research institutions and ministries) in the process of evaluating technological strengths, weaknesses and future needs. Most developed countries, and several newly industrializing ones, are undertaking technology foresight exercises (for the UK experience see Box 2).

Box 2: The UK Technology Foresight Programme

Increasing competition and the rising pace of technological change have led policy makers in several industrialized 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 and 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; each was chaired by a senior industrialist. 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 synthesized 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

Of this broad list, priorities were assigned to three categories of technologies: *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 in the UK. 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.

- Creating the technical manpower needed for advanced technological activity. In the new NIEs, one of the major constraints to technological deepening is the shortage of high level engineers and scientists of the right kind (Lall, 1995, 1998.b, 1998.c). We return to this below.

- Offering tax incentives for R&D. While there is debate about the effectiveness of tax incentives, most countries have settled at 100 per cent. Korea gave 125 per cent for some years. Thailand gives 200 per cent, which seems excessive, and in any case has failed to stimulate R&D, partly because the tax authorities have cumbersome procedures for evaluating genuine R&D.

- Strengthening linkages between the technology infrastructure (standards, metrology, quality and testing), public research institutes, universities on the one hand and industry on the other. In many countries, the public institutions related to technology have weak linkages with the productive sector and contribute little to technology development. Many countries are reforming these institutions, either privatizing large parts or subjecting them to market discipline (imposing hard budget constraints and forcing them to earn a specified portion from industry). They are also offering financial assistance for enterprises to contract R&D to research institutes (the World Bank had a very successful project to do this in India, called SPREAD, see Box 3). Given the rising importance of ISO 9000 quality management standards for export activity, many countries also offer assistance to firms for consultancy services for this purpose (the UK government did the same and so gave it a lead over other countries in certification). In fact, the promotion of ISO 9000 is becoming one of the benchmarks of technological competence, at least at the production level, and developing countries have to develop programmes of their own to do this effectively.

Box 3: Linking Industry with Technology Institutions: The SPREAD Programme in India

One important component of the World Bank's Industrial Technology Development project in India was aimed at 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, liaise 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 were 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.

The elements that account for the success of this project are: a 'matchmaking' intermediary (ICICI, a well-established private financial institution with intimate knowledge of industry) to administer the funds and overcome information and trust barriers between researchers and business; a technically-oriented unit in this intermediary to assess the viability of applications and to 'hold hands' as the projects developed (more like venture capitalists than bankers); the granting of finance in the form of loans rather than grants, with a substantial matching contribution by entrepreneurs; and significant efforts with technology institutions to help them understand the needs of industry and change their operating 'culture'.

- Supporting SME technology development. This is such an obvious and pressing need in all developing countries (and developed ones also) that it hardly needs emphasis. However, the nature of the problem is so difficult that it is difficult to mount effective programmes. Perhaps the best set of programmes in the Asia-Pacific region has been developed by Taiwan Province, which relies on SMEs for its high-tech exports and supports them extensively to meet the needs of rapidly changing technology (Box 4). One of the ingredients of success seems to be to have a very proactive approach, with well-qualified staff visiting enterprises and trying to define their technological needs and provide a whole package of assistance. A passive approach, by contrast, yields poor results. In many countries, this approach is compounded by time-consuming, complex bureaucratic rules and by an approach that focuses on technology to the exclusion of marketing, financing and training needs.

- Another approach adopted by Taiwan Province of relevance is at the cutting edge of innovation. This involves the government in forming strategic alliances between technology-based enterprises, with leading research institutions, to allow them to reach technological frontiers in key areas (Box 5). This approach assumes that enterprises with sufficient technological capabilities are already in existence – only applicable to countries with advanced industrial sectors and firms able to compete internationally in sophisticated activities.

- The government should launch comprehensive technical benchmarking of major industrial activities, comparing productivity, technical competence, quality, innovation and so on within the country and with major competitors. Such exercises are common in developed countries, and are

Box 4: SME Support in Taiwan Province

Taiwan Province has around 700,000 SMEs, accounting for 70% of employment, 55% of GNP and 62% of manufactured exports, and an impressive set of programmes to support them. In 1981, the government set up the Medium and Small Business Administration to support SME development and co-ordinate the several agencies that provided them assistance. 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 Joint Services Centre of the Ministry of Economic Affairs acts as a source of information on SME assistance. The government covers 50-70% of consultation fees for consultancy services for SMEs. The Medium and Small Business Administration has a fund for SME promotion of NT$10 billion. The "Centre-Satellite Factory Promotion Programme" of the Ministry of Economic Affairs integrates smaller factories around a principal one. This programme involves vendor assistance and productivity raising efforts, and a rational sharing of tasks between participating enterprises. By 1989 there were 60 networks with 1,186 satellite factories in operation, mainly in electronics.

For providing R&D support, ITRI handles contract research work considered too risky for the private sector; the contracts have financial support from the government. The Institute for the Information Industry (III), complements ITRI's work on hardware by developing and introducing software technology. The Taiwan Handicraft Promotion Centre supports handicraft producers, particularly small ones with export potential. The Programme for the Promotion of Technology Transfer maintains close contact with foreign corporations that have developed leading-edge technologies in order to facilitate the transfer of those technologies to Taiwan.

The China Productivity Centre (CPC) is the known for its efforts to promote automation to improve precision and quality; it sends out teams of engineers to visit plants throughout the country and demonstrate the best means of automation and solve relevant technical problems. Over two years the CPC visited over 1000 plants and made over 4000 suggestions for improvement. It also carried out more than 500 research projects on improving production efficiency and linked enterprises to research centres to solve more complex technical problems.

often carried out by firms themselves or by industry associations. In developing countries, however, such efforts are relatively rare. This means that the government has little idea of competitiveness problems in the country and enterprises are unaware of how they rank *vis-à-vis* their main competitors abroad.

Box 5: Taiwan's technology development through alliance formation

IBM unveiled its first PC based on the new PowerPC microprocessor, a product made by the alliance of IBM, Motorola and Apple, 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. Its specific purpose was to transfer, master and diffuse the new PowerPC technology over 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 Taiwanese government 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. These 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 identified the products, tapped channels of technology transfer, mobilizing 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.

- Finally, the government can launch R&D in universities and create a centre of excellence that attracts enterprise attention. Singapore has used this as a strategy to create new technological capabilities in innovation (Box 6).

5.2 Creating industrial skills

As the industrial sector grows more complex and sophisticated, the challenge of providing better and more appropriate human capital becomes more important. But the need in the new paradigm is more urgent. As the pace of technical change accelerates, and competition becomes more open, specialized state-of-the-art skills become critical to competitiveness. Traditional methods of education and training often prove inadequate to the need. New institutions need to develop and firms to become more conscious of the importance of employee training. In the traditional setting, industrial development required simply improving the quantity and quality of primary schooling and basic technical education, and encouraging all forms of in-firm training. In the future, there has to be greater emphasis of high-level, specialized training, with close interaction between education and industry to assess and communicate evolving needs. This is a more difficult process. Many countries are failing to keep pace with the need.

Box 6: Singapore's Institute for Molecular and Cell Biology (IMCB)

A good example of the successful use of various government policies, institutions and financial instruments is Singapore's move into the scientific mainstream with the development of the Institute of Molecular and Cell Biology (IMCB). The IMCB is an ambitious project in the government's overall strategy to use high technology to strengthen its economy. The government places this within the National Biotechnology Programme, started in 1988 to strengthen the national R&D base and fund biotechnology development. An important incentive under this programme is pioneer industry status, which gives tax exemption for 5-10 years, with the largest benefits directed at technology-intensive and export-oriented projects. In addition, funding is provided by the government if there is active research collaboration with the public sector, with no specified limit to the available funding for R&D. Supporting this effort is a strong push in basic research at the National University of Singapore (NUS), which houses the IMCB. The University conducts one-third of Singapore's R&D, and NUS scientists have made their mark in several areas including materials technology, microelectronics and information technology.

Singapore's decision to spend S$13.8 million to build IMCB and to provide annual funding of S$17.5 million was part of a broader approach to develop biotechnology. The government believes that this field fits the country's need (e.g., it requires few natural resources, has high value-added, and can make strategic use of Singapore's global business networks). To nurture this industry, the EDB established Singapore Bio-Innovation (SBI) Pte Ltd., which by 1991 had invested S$41 million in 12 local biotech start-up firms with 1,428 employees making health care, food, and agricultural products. SBI also invests in overseas companies that might be strategic allies.

The investment in IMCB appears to be paying off scientifically. An IMCB group is at the forefront of research on tyrosine phosphates, a hot topic in cancer research. Another group is sequencing the genomes of several fish species, which could serve as a reference vertebrate genome for the human genome project. IMCB laboratories innovative assay systems convinced Glaxo, the pharmaceutical MNC, to establish a S$31 million trust fund for a drug screening centre within IMCB. Glaxo also invested S$30 million for a neurobiology lab to conduct research on degenerative brain disease.

Encouraged by these successes, the government expanded IMCB's research base by establishing the Bioscience Centre, which provides facilities for research at NUS and the Food Biotechnology Centre. The Bioprocessing Technology Unit, opened in 1990, seeks to improve purification, synthesis and fermentation methods for commercial production. The lab recently achieved large yields of TNF-[beta], which other companies, including Genzyme in the US and Boehringer Mannheim in Germany, are keen to put into clinical cancer trials. The National University Medical Institute, being built near IMCB and the National University Hospital, is modelled on the US National Institutes of Health.

Over the years, Glaxo has strengthened its research relationship with IMCB. An R&D venture was started in 1992, and a new Centre for Natural Product Research was launched in 1994. This Centre has discovered some 60-90 novel compounds with promise of further development. Boehringer Mannheim has undertaken another collaboration on colorectal cancer. US companies like Pfizer and Amylin have awarded research contracts. The staff has published over 500 research papers in leading journals and filed several patents.

One obstacle to Singapore's quest for scientific success is its shortage of well-qualified scientists and engineers. To overcome this, the IMCB recruited for scientists from the West offering them research freedom, ample funding and salaries of up to $50,000 for principal investigators. Those who accept IMCB's offer may qualify for renewable 3-year contracts. Singapore's own students represent the largest source of scientific talent at IMCB. Singapore's two polytechnics are training technicians to fill the growing demand from biotech labs and industries. In addition to tuition, graduate students at IMCB receive a handsome ($10,000 a year) stipend.

Let us look at patterns of educational enrolments in developing world. These data are not the ideal way to measure skill creation, since it excludes on-the-job learning and training. Enrolment data may not be a sound indicator even of formal education: dropout rates differ, as do the quality and relevance of the education system for industrial needs. Nevertheless, they are the only data available on a comparable basis, and the rates do say something about the base for skill acquisition. Table 7 shows the total numbers enrolled in tertiary education and in the three main technical subjects (science, mathematics/computing and engineering) by region in 1995 (weighted by population). The Asian

Tigers enrol over 33 times the proportion of their population in technical subjects that in Sub-Saharan Africa (including South Africa). The ratio is twice that of industrial countries, nearly 5 times Latin America and the new Tigers, and over 10 times South Asia and China. The leading 3 countries in terms of total technical enrolments – China (18%), India (16%) and Korea (11%) – account for 44 percent of the developing world's technical enrolments, the top ten for 76 percent and the top 20 for 93 percent.

Let us look more closely at enrolments in the subject most directly related to technological competitiveness: *engineering*. Figure 2 shows the top 30 developing countries by this measure. The leader, by a significant margin, is Korea, followed by Taiwan, Chile and Colombia. Singapore appears in sixth place while large economies like China are near the bottom. Argentina comes 13th (37th if developed and transition economies are included). Interestingly, Korea also leads the whole world in engineering enrolments (as well as technical enrolments).[8]

Singapore's figure should be treated carefully, since it excludes enrolment in its polytechnics. These provide high quality technical education, which in other countries may be counted as full tertiary institutions. In addition, Singapore has one of the most comprehensive and ambitious worker training programmes of the NIEs (Box 7). If we take these into account, we can conclude that the Tigers with the strongest technological ambitions, Korea, Taiwan and Singapore, have invested most in training high level technical manpower. Chile comes out very near the top, but its lack of technological dynamism is clearly traceable to its lack of coherent and targeted industrial policy: its technological performance has not lived up its skill base.

Table 7: Tertiary level enrolments and enrolments in technical subjects (1995)

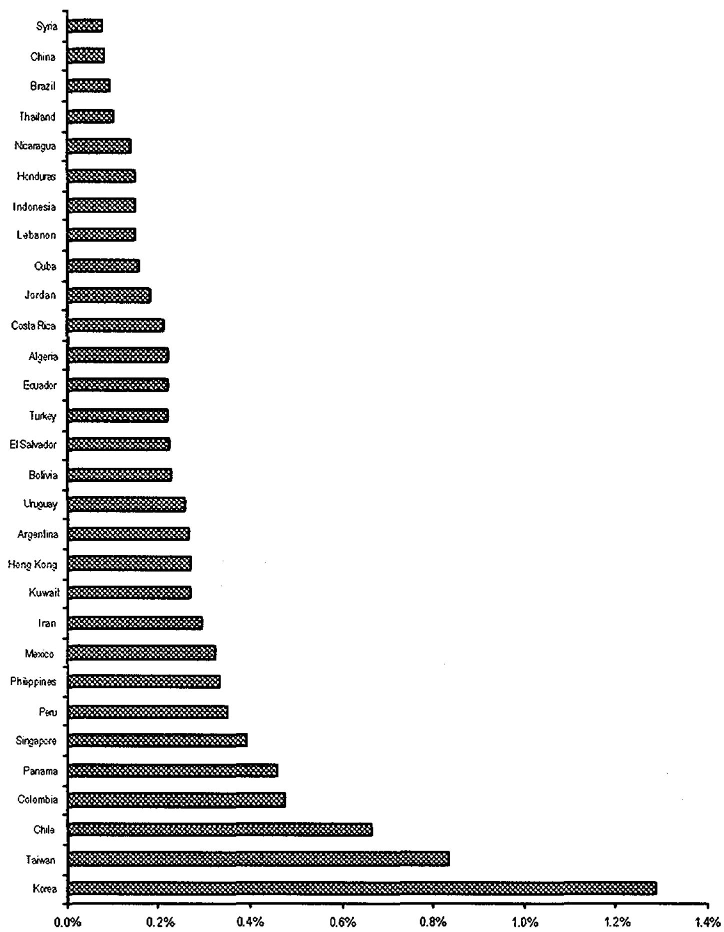
	3 level enrolment		*Technical enrolments, numbers & % of population*							
	Total	*% pop.*	*Natural Science*		*Math's, computing*		*Engineering*		*All Technical subjects*	
	No. students		*numbers*	*%*	*numbers*	*%*	*numbers*	*%*	*numbers*	*%*
Developing countries	***35,345,800***	***0.82%***	***2,046,566***	***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 economies	***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 mature Tigers, by contrast, integrated their human capital strategies closely with their industrial policies, ensuring that targeted activities had access to the skills needed. They encouraged foreign education and attracted back of trained nationals. Moreover, governments did not have to provide substantial direct funding for higher education: in Korea, for instance, the bulk of higher education is

[8] The top 5 countries are Korea, Finland, Taiwan, Chile and Japan.

Fig. 2: Engineering enrolments in developing countries (% pop. 1995)



funded privately, with the government playing a guiding and catalytic role. In Singapore, by contrast, the government had to fund higher education extensively.

Let us say a few words about *Korea*. Korea has the highest educational attainments relevant to industry of any developing (and developed) country, the only close competitor being Taiwan. Its secondary and tertiary level enrolments (at 90 and 40 per cent respectively) are at developed county levels. Dropout rates are very low and the quality of the education, as judged by international comparisons of numeracy and science tests, is very good at imparting numeracy. It has impressive levels of vocational training enrolments, and encourages significant in-firm training of employees. It has the highest relative enrolments in science and technology subjects at universities of the East Asian countries, a conscious strategy of the government to raise technology development to levels of developed countries. The government's manpower planning was based explicitly on projecting the need for high level technical manpower with highly industrialized nations like Japan, Germany and the USA.

The education of high-level technical manpower was promoted by the setting up of institutions like KAIST (Korea Advanced Institute of Science and Technology) at the post-graduate level and KIT (Korea Institute of Technology) at the undergraduate level. These were aimed at exceptionally gifted students, while the normal university system catered to the normal run of science and engineering training. An example of educational targeting in support of industrial strategy is the strategy to upgrade electronics design skills. In 1988 the Korean government began funding the Seoul National University's semiconductor laboratory to train a new generation of chip designers. The laboratory mounted annual programmes for about 200 students and employees of private firms, and some of the work for Korea's highest profile electronics project, the development of a 64 megabit DRAM chip, has been conducted at this laboratory. About 70% of the money is distributed to students and faculty at smaller universities for use in related research efforts. The laboratory, with about Won 10 billion of equipment, is also involved in materials analysis.

Korea has also strongly encouraged in-firm training. The government levied a 5 per cent payroll tax on large firms, refundable if they undertook employee training in approved programmes. While such payroll taxes are found in many countries, the level set in Korea was exceptionally high (most others range around 1 per cent). The levy was lowered after a few years, but it stimulated a training culture

Box 7: Human Capital Formation for Industrialization 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 specialization 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. This is worth describing at some length. Singapore is a regional leader in employee training programmes held outside the firm.

The Vocational and Industrial Training Board (VITB) established 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 comprise 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 (one Indian, one German and one 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 National Productivity Board's Skills Development Fund (SDF) created 405,621 training places in 1990. 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 organizations. 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 specialized 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.

among the larger firms, helping them to cope with the sharply rising needs for new skills with the push into heavy and high-technology industry. It probably also reflected the initial reluctance of firms to invest in employee training, since there was no tradition of in-firm training, and the lack of a lifetime employment system (unlike Japan, where firms invest heavily in upgrading employee skills) reduced employers' ability to appropriate returns to these investments.

Another way to evaluate the relative skill performance of countries is to compare an index of skills over time. The classic work on skills by Harbison and Myers (1964) derived an index for national skill levels using data for 1957-58 for 65 countries. This index was based on secondary school enrolments plus tertiary enrolments multiplied by five (both enrolments as percentages of the age group). We have worked out the Harbison-Myers index – called HMI – for 1995.

Table 8 shows the 65 countries covered by the original HMI ranked according to their skill levels in 1995. It also gives the original ranks assigned by Harbison and Myers. Rich industrial countries hold the top 9 places. Of these leaders, Canada, Finland and Norway have improved their ranks significantly. The first developing country on the list is Korea, which also improves its rank significantly. Taiwan comes next, with a slight improvement (Singapore and Hong Kong were not in the original HMI). Of the large countries, China and Brazil retain their previous ranks exactly, while Argentina, Mexico, India and Pakistan deteriorate. Of the new Tigers, Malaysia and Thailand remain at their original ranks, while Indonesia improves (Philippines was not included). Annex Table 2 shows the complete list of HMI ranks, tertiary technical enrolments and R&D spending for all countries in the world on which data are available.

Table 8: HMI ranks, 1995 and 1957-58

1995		1957-58	1995		1957-58	1995		1957-58
1	Canada	9	23	Argentina	14	45	Malaysia	45
2	Australia	3	24	Poland	20	46	Indonesia	53
3	USA	1	25	Peru	37	47	Brazil	47
4	Finland	11	26	Uruguay	18	48	China	48
5	N. Zealand	2	27	Lebanon	44	49	Jamaica	39
6	Belgium	5	28	Chile	27	50	Paraguay	45
7	Norway	17	29	Costa Rica	29	51	Zimbabwe	60
8	Netherlands	4	30	Czech	19	52	India	34
9	UK	6	31	Hungary	25	53	Congo	59
10	Korea	23	32	S Africa	31	54	Myanmar	52
11	France	8	33	Yugoslavia	21	55	Nigeria	57
12	Spain	32	34	Egypt	30	56	Cote d'Ivoire	61
13	Sweden	15	35	Thailand	35	57	Ghana	46
14	Denmark	16	36	Colombia	46	58	Pakistan	42
15	Germany	12	37	Ecuador	43	59	Senegal	56
16	Russia	10	38	Bolivia	51	60	Kenya	58
17	Japan	7	39	Turkey	38	61	Afghanistan	64
18	Italy	22	40	Cuba	33	62	Sudan	54
19	Greece	26	41	Iran	49	63	Uganda	55
20	Israel	13	42	S Arabia	63	64	Ethiopia	65
21	Taiwan	24	43	Mexico	36	65	Tanzania	62
22	Portugal	28	44	Tunisia	50			

Now let us consider the policy needs for skill development in the new paradigm.

The first step in devising a skill strategy is, as with technology, to *benchmark* the education and training system against major competitors. For instance, the UK Government launched a Skills Audit to compare the skill levels of young people in the UK against those in France, Germany, the USA and Singapore. This is not a straightforward exercise. However, after adjusting for quality, duration and so on, it is possible to come to meaningful assessments of how effective national systems are; the evaluation is easier if the focus is on narrow categories of skills.

The next step is to address the various market failures in the demand and supply of education. A huge variety of policy responses exist, ranging from public provision of training to largely private led systems. It is beyond the scope of this paper to consider these at any length.

However, we should comment briefly on the vocational education and training system, particularly relevant to the creation of technical skills. The ILO's *WER 1998-99* devotes a chapter to the analysis of training systems, and differentiates between three broad categories (Table 9):

1. *The cooperative system*: Here training is left neither to employer or employee decisions nor to government planning, but emerges after interaction between the three parties. This generally involves strong workforce representation on works councils. Germany is the best known example of this system. Employers offer apprenticeship in all sectors, taking in over half the relevant age group. Chambers of Industry and Commerce are heavily involved in registering apprentices and setting qualification standards. Training is provided by public vocational schools, with half the cost borne by employers; the apprentices also make a contribution by taking low wages. The qualifications are nationally recognized, and poaching is discouraged by strong unions. This is the basis of the famous 'high skill equilibrium' in Germany. A number of Latin American countries also have a similar system based on vocational training institutions.

Table 9: Main Types of Training Systems		
System	Examples	Main Features
Cooperative	Austria, Germany, Switzerland, many Latin American countries	Pressures to train from cooperation between employers' organizations, government and trade unions
Enterprise based		
1. Low labour turnover	Japan	Low labour mobility, lifetime employment, absence of stock-market pressures
2. Voluntarist	UK, USA	Few institutional pressures to train
State driven		
1. Demand led	Hong Kong, Korea, Singapore, Taiwan	State plays leading role in coordinating demand for and supply of skills, in open competitive environment
2. Supply led	Economies in transition; many developing countries in Asia and Africa	Government takes prime responsibility for training in institutions. Little pressure for employers to train.

2. *Enterprise based systems*: These rely primarily on training provided by enterprises, with Japan on the one hand (providing massive amounts of training to long-staying employees) and the USA and UK on the other (with voluntary training). This system is often blamed in the UK for its 'low skill equilibrium' while in the USA the deficiencies of enterprise training are apparently offset by a large supply of high level engineering skills.

3. *The state-driven system*: This also has two variants. The mature NIEs had a strong role of government in meeting fast-changing skill needs. In Korea, in particular, the government created skills in advance of setting up new industries. The other variant is state led education in former socialist economies as well as in many developing countries.

The conclusion reached by the ILO is that "There is no *ideal* training system" (p. 82). Yet all systems are under tremendous pressure as competitive forces mount and technical change proceeds unabated. It is imperative for governments to respond to these pressures if they are to participate fully and gainfully in globalization (and staying out is no longer a viable option). How they should respond in particular social, economic and institutional settings is a complex matter to which there is no general solution.

The *WER 1998-99* points to four elements of a general response:

1. *Social partnership*: The need for close collaboration between employers, workers and the state to determine skill needs and the most effective ways of meeting them.

2. *Co-financing*: Governments can no longer be expected to meet the burden of training and education costs, and means have to be found of inducing individuals and enterprises to finance them. This also involves making the delivery of training more efficient and relevant, improving capital markets and monitoring skill needs on a regular basis.

3. *Certification*: This is necessary to improve labour transferability and so efficient labour markets.

4. *Cost effectiveness:* This involves decentralization of decision making and the increasing participation of private training providers. This still requires considerable support and monitoring of standards by the government.

5.3 FDI

World trade, and so competitiveness, is increasingly related to TNC activity. TNCs now account for very large shares – over two-thirds – of world trade (UNCTAD, *WIR 1996*). Their shares are higher in technologically advanced and differentiated products, and are rising in response to liberalized trade and investment policies. This may seem surprising in view of the fact that TNCs are increasing their international production, which can substitute for exports. However, international production does not replace the export of products at the top of the technology scale (from headquarters or from other advanced affiliates) or at the bottom (from affiliates in low wage countries).

It also raises trade in intermediate products. A very large part of TNC trade is now *intra-firm.* In the USA, for instance, exports by TNCs to their majority-owned affiliates in 1996 comprised 48% of parent company exports, up from 41% in 1977. Half of exports by foreign TNCs in the USA (accounting for 20 per cent of total US exports) were also intra-firm. The propensity to engage in intra- as compared to inter-firm trade is again higher in the more technologically complex and novel products. Similar trends are likely to exist in other major capital exporting countries.

This suggests that entry into a large (and most dynamic) part of world industrial trade by developing countries requires the participation of TNCs. This holds even more for the most dynamic products in trade: complex, technology intensive and differentiated manufactured products. However, few developing countries are able to participate in this dynamic system of TNC trade and production. FDI flows to the developing world are rising rapidly (Table 10), from an average of $29 billion in 1986-91 to $149 billion in 1997. But the flows to the developing world are highly concentrated. The top 10 countries account for nearly 80 percent, the top 25 for 95 percent.

Table 10: FDI Inflows, 1986-97

	INFLOWS ($ m)							INFLOWS (shares)	
	1986-91 Ave.	**1992**	**1993**	**1994**	**1995**	**1996**	**1997 (prov.)**	**1986-91**	**1997**
World	159,331	175,841	217,559	242,999	331,189	337,550	400,486	100.0%	100.0%
Developed countries	129,583	120,294	138,887	141,503	211,465	195,393	233,115	81.3%	58.2%
West Europe	66,470	85,837	83,877	78,417	122,779	99,954	114,857	41.7%	28.7%
North America	54,674	23,662	48,302	53,571	69,596	82,851	98,994	34.3%	24.7%
Other	8,439	10,796	6,708	9,515	19,090	12,588	19,263	5.3%	4.8%
Developing countries	29,090	51,108	72,528	95,582	105,511	129,813	148,944	18.3%	37.2%
North Africa	1,196	1,582	1,579	2,364	1,262	1,313	1,811	0.8%	0.5%
Sub-Saharan Africa	1,673	1,589	2,068	3,329	3,874	3,515	2,899	1.1%	0.7%
Latin America, Caribbean	9,460	17,611	17,247	28,687	31,929	43,755	56,138	5.9%	14.0%
Developing Europe	88	214	264	405	467	1,029	796	0.1%	0.2%
West Asia	1,329	1,827	3,447	1,518	-746	303	1,886	0.8%	0.5%
Central Asia	4	142	424	896	1,561	2,084	2,627	0.0%	0.7%
South and East Asia	15,135	27,683	47,348	58,265	66,571	77,624	82,411	9.5%	20.6%
Central and Eastern Europe	658	4,439	6,143	5,914	14,214	12,344	18,424	0.4%	4.6%
				Memo Item					
Least Developed (43)	781	1,463	1,747	844	1,096	1,965	1,813	0.5%	0.5%
African LDCs	590	470	558	548	880	1,214	1,162	0.4%	0.3%
Oil exporting (24)	8,786	15,019	17,214	23,820	21,786	24,106	30,890	5.5%	7.7%

Source: UNCTAD, *World Investment Report 1998*.

Table 11 shows FDI inflows as a percentage of gross domestic capital formation in the leading developing countries. It illustrates the differences in the contribution to relative industrial development made by TNCs. At one end, the two larger mature NIEs, Korea and Taiwan, have had relatively low reliance on FDI, and used restrictions on foreign entry as a deliberate tool of industrial policy. At the other, Singapore has drawn upon FDI heavily, with Malaysia following. Thailand has about the same level as Taiwan, except that in Thailand most high-tech export activity is concentrated in TNCs while in Taiwan it is led by local companies.

Table 11: Inward FDI flows as Percentage of Gross Domestic Investment						
	1985-90	2	1992	1993	1994	1995
WORLD	5.4	3.1	3.3	4.4	4.5	5.2
Regions						
All Developed	5.5	3.2	3.2	3.7	3.5	4.4
W. Europe	8.9	5.3	5.3	5.8	5.1	6.7
N. America	5.5	3.4	2.5	3.8	5.5	4.6
All developing	8.0	4.4	5.1	6.6	8.0	8.2
N. Africa	2.7	2.2	3.8	4.1	5.7	3.0
Other Africa	9.2	7.3	6.4	8.2	12.5	13.2
L. America	11.3	7.8	8.1	7.2	10.3	11.0
W. Asia	1.2	1.7	1.5	2.2	1.0	-0.6
S. & E. Asia	9.7	3.8	4.7	7.5	8.3	9.0
C. & E. Europe	1.0	0.4	0.8	7.9	5.0	5.2
Selected Developing Countries						
H Kong	12.2	2.3	7.7	7.1	8.2	8.4
Singapore	59.3	33.6	12.4	23.0	23.0	24.6
Korea	1.9	1.0	0.6	0.5	0.6	1.1
Taiwan	5.1	3.1	1.8	1.8	2.5	2.7
China	14.5	3.3	7.8	7.1	8.2	8.4
Indonesia	7.6	3.6	3.9	3.8	3.7	6.5
Malaysia	43.7	23.8	26.0	22.5	16.1	17.9
Thailand	10.2	4.9	4.8	3.4	2.3	2.9
Philippines	13.6	6.0	2.1	9.6	10.5	9.0
India	1.2	0.3	0.4	1.0	2.4	3.6
Pakistan	5.1	3.3	3.5	3.5	4.6	6.7
B'desh	0.3	0.1	0.1	0.4	0.3	..
S. Lanka	6.9	2.4	5.4	7.5	5.3	2.0
Argentina	13.0	15.1	25.5	31.0	4.8	11.7
Brazil	3.1	1.4	3.0	1.3	3.0	4.7
Chile	21.5	7.3	7.2	6.9	14.0	10.8
Mexico	16.9	8.5	6.4	6.0	14.3	17.1
Egypt	3.1	2.8	5.3	6.4	14.8	7.2
Morocco	8.5	5.1	6.6	8.0	8.8	4.1
Tunisia	14.7	4.0	12.5	13.7	10.2	6.1
Turkey	3.5	2.3	2.3	1.4	1.6	2.2
Côte d'Ivoire	-0.6	2.1	-29.1	10.7	3.3	1.5
Ghana	17.8	2.3	2.5	9.4	22.6	22.2
Kenya	1.3	1.2	0.5	0.2	0.3	1.7
Mauritius	4.5	2.4	1.7	1.6	1.9	1.9
Nigeria	34.9	19.8	26.3	36.5	50.5	50.0
Uganda	8.4	0.2	0.6	10.1	12.6	21.1
Tanzania	3.3	0.3	1.1	2.0	-0.4	..
Source: UNCTAD, *World Investment Report 1997.*						

The deliberate restriction of FDI as a tool for promoting technology development is based on the idea that TNCs are an effective means of transferring know-how but not of deepening local capabilities to the innovative stage. There is validity in this view, and countries that have managed to restrict FDI but kept other means of access to foreign technology open, while providing local firms the stimulus, skills and finance to undertake R&D have done very well. At the same time, many countries that restricted FDI and other forms of technology import, provided heavy protection, but failed to provide the inputs needed for technology development, merely created inefficiency and technological lags.

TNCs will play a much more important role in the new industrial paradigm. As noted, this is not simply because the rules of the game will make it practically necessary to allow freer foreign entry and offer TNCs equal treatment with domestic enterprises. It is also because globalized production is much larger and international production systems more widespread and dynamic. Many new technologies are not available in other forms than direct TNC participation, and the cost and pace of technical change makes nationalistic strategies more costly and risky. Moreover, a few developing host countries are attracting advanced technological activity, including frontier R&D, by TNCs.

In this context, therefore, policies towards FDI have to be much more liberal – but they do not have to passive. The foreign investment process suffers from a number of market failures. TNCs do not have full information on investment possibilities across the developing world, or do not interpret the evidence they have properly. More importantly, it is possible for host governments to gear their factor markets to specific competitive needs of potential investors and so raise their attractiveness significantly. This is the rationale for FDI promotion and targeting, so successfully practised by Singapore (Box 8). The judicious use of incentives, factor market interventions and pressures, guided by a vision of industrial development, can help governments extract greater benefit from TNCs than a passive *laissez faire* policy.

It is important to not to confuse proactive FDI strategies with offering massive tax incentives or grants to investors. Effective FDI strategy may use fiscal incentives as one of a large array of tools to attract, target and upgrade investments, but it is a fairly small tool. Where other conditions for competitive, high value-added investments – skills, infrastructure, technical support, supplier networks, efficient administration and low business costs – are not present, throwing money at investors may attract some

Box 8: Singapore's FDI Strategy

Singapore started, like Hong Kong, with a strategic location and established *entrepôt* facilities, but with a smaller base of trading and financial activity. Despite a tradition of shipbuilding and associated skills, Singapore had a weak entrepreneurial tradition and did not have an influx of experienced businessmen and technologists from Mainland China. Nor did it have access to a large, poorer but culturally similar hinterland to which it could sell its services. After a spell of import substitution, Singapore switched to free trade and pursued growth through aggressively seeking and targeting foreign direct investment, while raising domestic resources by various measures. Moreover, it deepened its industrial and export structure by using incentives to persuade MNCs to move from labour to capital, skill and technology-intensive activities. Its knowledge 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 MNC production, drawing on the flow of innovation generated by the firms and investing relatively little in its own innovative effort.

Singapore invested heavily in education and training and physical infrastructure to attract high quality foreign investment. Its policies for attracting FDI were based on liberal entry and ownership conditions, easy access to expatriate skills, very efficient and honest administration, and generous incentives for the activities that it was seeking to promote. In 1961, it set up the Economic Development Board (EDB) 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. The government carried out periodic exercises to evaluate economic competitiveness and devise strategies to upgrade it. The last report (MTI, 1998) builds upon the earlier 'cluster' approach adopted by the EDB to drive investment and infrastructure into the information based sector and create new areas of competitive advantage.

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 it to enter. While the main thrust of Singapore's technology import policies was to target FDI, the government also sought over time to increase linkages with local enterprises by promoting subcontracting and improving extension services.

The decisions of TNCs about what new technologies to bring were strongly influenced by the incentive system, the provision of infrastructure, and the direction offered by the government. The government itself responded (or anticipated through proactive planning and consultation) by providing the necessary skilled manpower, often in consultation with TNCs. 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 TNCs 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 programmes 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. Box 4 describes some ways in which the government sought to enhance spillover effects.

As labour and land costs rose, the Singapore government used the opportunity to encourage TNCs to reconfigure their operations on a regional basis. Special programmes were launched to make Singapore attractive as a base for regional marketing, distribution, service, and R&D centres to support manufacturing and sales in the region. To promote such reconfiguration, new incentives such as the Regional Headquarters scheme, the International Procurement Office scheme, the International Logistics Centre scheme, and the Approved Trader scheme were introduced. The Regional Headquarters scheme has been particularly successful in attracting a number of high value and skill-intensive activities to Singapore.

TNCs, but it is unlikely to attract the kinds of investments needed for long-term competitiveness. On the other hand, where the government can create such conditions to woo particularly desirable investments, fiscal incentives should be a marginal element, to be used if necessary to persuade investors to select a particular site or undertake a particular task.

5.4 Incentive systems

By 'incentive systems' is meant not the fiscal incentives just mentioned, but the trade and industrial policy regime within which enterprises function, and which filter the market signals to which they respond. We have already noted that the new paradigm will necessitate much greater reliance on market forces than before. It will lead towards international convergence in legal and administrative rules, with much greater stability, transparency and non-discrimination. It will reduce the element of transactions costs in doing business in all forms across national boundaries, whether by direct investment or otherwise. It will entail tighter intellectual property protection and greater freedom of movement of skilled personnel (but not, in the foreseeable future, unskilled workers). It will increase the spread of integrated production system, with different processes in a single chain spread over countries and regions.

The forces driving these changes are largely technological, and so, in my view, irreversible. This does not mean that they are necessarily beneficial for all participants. In essence, the imposition of free markets imposes harsh discipline on all players, and it does not lead to *efficient* outcomes where markets are deficient and where supporting institutions do not exist or fail to perform their functions. It certainly does not lead to *equitable* outcomes. Economies that are able to create the necessary capabilities and institutions to gain from market forces do much better than those that wait passively and let market forces in to exploit their endowments. Governments that are able to distribute the abilities and skills to prosper in the new technology driven paradigm create much greater equity than those that release market forces within traditional (skewed) systems of privilege and wealth.

The way forward is not to rely on free markets to make the best use of existing endowments, but to create new endowments and distribute them better. There is, in other words, considerable scope for industrial policy in the new paradigm, but the nature of the policy has to be very different from before. We have already indicated some of the salient features of the new policy paradigm. Let us now conclude with some thoughts on the role of international institutions like UNIDO.

6. Role of international organizations and UNIDO

The role of international organizations like UNIDO in the new paradigm derives from the potential inefficiencies and inequities we have just noted. The imposition upon developing countries of globalized free markets can yield efficiency benefits, but it may also create its own costs and exacerbate inequality and marginalization within and across countries. These problems arise from market and institutional failures and the lack of ability of many countries to cope without careful preparation for the competitive world. Rapid and sweeping exposure market forces, often envisaged as ideal under the new paradigm, can be effective in using the *existing* endowments of economies. However, this may not lead to sustained development. Sustainability needs the dynamizing of static endowments. This, in turn, needs vision and targeted policy intervention.

The evidence from the Asia-Pacific region shows clearly that good policy makes all the difference. 'Good policy' means, not a passive approach relying on existing factor markets and institutions to drive growth in liberalized markets, but a proactive approach that builds new capabilities and institutions. This 'market stimulating' approach sets up a vision of future development that goes beyond remedying market failures in the narrow sense (Lall and Teubal, 1998). It then designs strategies and policies to realise that vision, retaining the flexibility to change course as events evolve, and, most importantly, building in policy learning into the strategy. Policy learning is vital because many actions needed to build dynamic competitiveness go into uncharted territory, where there is little theoretical or practical precedent. Policy makers thus have to learn, in concert with the main players involved, locally and abroad.

In view of these considerations, the role that an institution like UNIDO has to play in the new paradigm may have some of the following elements:

- Analyse the competitive parameters within which developing countries have to operate. This involves in-depth surveys of the technology, skills, trade patterns, TNC involvement and logistic needs of major industries of interest to development. The objective of such surveys is to overcome informational and analytical gaps facing policy makers in developing countries. For instance, many governments in the Asia-Pacific region would benefit from a detailed analysis of the patterns of competitiveness in the clothing industry once the MFA regime ends in five years. Which technologies and skills will be most relevant? Which countries may be well placed, given their labour costs, to retain or increase market shares in the face of free competition from large countries like China and India? What do countries need to do to enhance their competitive position? And so on.

- Benchmark at various levels. At the most general level, international organizations can use their access to up-to-date international information to compare the export, production, investment, productivity and technological performance of countries. At the most detailed level, they can help enterprises benchmark their technical performance against each other, within and across countries. Between these two levels, there is scope for benchmarking sectors, policies, institutions and government departments. While many governments realise the value of such work, the techniques and information required are often outside their reach. UNIDO can, for instance, help members greatly by instructing them on useful benchmarking techniques and building a database they could draw upon. In the UK, large companies use the PROBE benchmarking database to evaluate themselves against several thousand European leaders. This benchmark is produced by the Confederation of British Industry; a developing country government could encourage the private sector to launch a similar effort. The UK government offers benchmarking services to SMEs to help raise their technological levels.

- Offer assistance to formulate sectoral competitiveness strategies. Where providing information and analysis is not felt to be sufficient, UNIDO could offer direct assistance to countries in developing industrial strategies to meet the most urgent needs of upgrading. This would require UNIDO itself to develop new capabilities, but essentially it would involve it in coordinating expertise already in existence.

- Help governments improve the technology infrastructure. Many governments tend to neglect the basic infrastructure that allows enterprises to improve their technological capabilities: standards, testing, metrology, contract research, information and extension. There are few benchmarks available to assess the effectiveness of existing institutions, and industry itself is largely ignorant of their potential contribution. There is now considerable experience on technology institution reform in European countries and also the developing world. UNIDO could offer to transfer the necessary experience and directly help in the upgrading of institutions. Unlike the usual supply push approach to technology, the new paradigm requires that institutions be made to serve industrial needs and earn much of their living by selling their services. Particular needs are the encouragement of ISO 9000 and 14000 standards, strengthening of testing and calibration services (with greater accreditation of private providers) and improving links between research laboratories and industry.

- SME support. This is clearly a massive and pervasive need, but since there is another session devoted to the topic there is no need to dwell on it at length here.

- Technology finance. There is a growing need for specialized financing of technological activity in developing countries. While many countries have an active venture capital industry, few have funds devoted to technology start-ups. The special skills needed have to be created, and there is generally a need for government support to get the industry established. Yet experience shows that there is a large pent-up demand for technology finance, particularly in countries with a long history of industrial production and a base of qualified people able to start technology based ventures (see Box 9 on India). While UNIDO is not equipped to enter this sort of financial field, it may well be able to help countries to undertake the preliminary explorations and training required.

- Encourage enterprise training. It is difficult to overemphasis the significance of enterprise training in to industrial competitiveness, yet it is generally the case that firms under-invest in training their employees. They are often unaware of the productivity and technological benefits of raising the skills of the workforce, or do not know how to go about providing effective training. Most fear that employees will leave for competitors after the training. A study undertaken by the World Bank (Tan and Batra, 1995) suggests that a sizeable proportion of enterprises in developing

Box 9: Indian Technology Start-ups Supported by Venture Capital— A Few Examples

VXL Instruments, Bangalore: This company was launched in 1987 by five engineers, four with electronics training from the Indian Institute of Technology, to make 'intelligent' monitors for computers for specialized use in hospitals, railways and industry. These have finer resolutions than normal monitors and have a great deal of in-built software to decode complex information. The products were developed in-house, and in 1995-96 its sales reached $13 million, of which 35% came from exports to Japan, UK and USA. It employs 500 people, of which 70 are in R&D (R&D expenditures account for over 4% of sales). Its prices are much lower than competitors in Korea and Taiwan, and its software capabilities are more advanced. It has ISO 9002 certification. It invests heavily in training its engineering and technical staff. It is setting up a new wholly export-oriented unit to make colour monitors for the USA.

Lumen Cables, Gujarat: This company was started in 1993 by a metallurgical engineer to make ultra-fine magnetic wires with multiple insulating coats of polyutherane, only 16-45 microns in diameter, for use in quartz watch movements and telephone voice coils. This is one of only eight such facilities in the world, and the market used to be dominated by a few producers. The small plant (18 employees) exports all its output through a buyer in Hong Kong, and is around 20% cheaper than competitors. The technology used was originally imported from Switzerland, but considerable technical effort was needed to master and adapt it; in the process, the capacity of the machinery was raised by over 50%, product endurance was improved and processes were changed to enable coloured wires to be made. Significant expansion is planned in the near future.

Astra Microwave, Hyderabad: This firm was started in 1993 by seven technocrats who used to work in defence R&D, and makes sophisticated telecommunications components such as ferrite, filters, sources, antenna and so on. The firm has a 75% market share in India, and has started exporting to Japan and USA. By 1996 its exports reached $1 million, about two-thirds of its output. Exports fetch 40% more than domestic sales, and import content is very low (15%). Of its 120 employees, 40 are graduate engineers and 35 are technicians. It has been certified for ISO 9001.

Labroton Instruments, Ambala: The promoters were a business family making glass products, and developed the technology for making laproscopes (sophisticated optical medical instruments) and research microscopes indigenously. The product was 'reverse engineered' from foreign models, and went through a long and difficult development process; two US buyers provided technical advice on improving it and bringing it to world standards. The product is now being exported to the USA at half the price of competitors (all in developed countries); the unit will soon become fully export-oriented. It is getting ISO 9000 certification.

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. This suggests that several constraints on training – such as poor information about the benefits of training, high training costs, the inability to exploit scale economies in training, weak managerial capabilities, absence of competitive pressures, or market imperfections – may be at work. There is much that UNIDO can do, perhaps in collaboration with the ILO, to help governments formulate better training strategies geared to industrial competitiveness.

These are some ideas out of a large possible range of actions that UNIDO and related international institutions can undertake. Of course, many of them are already on their agendas, along with a host of detailed analytical and technical assistance measures; only a detailed evaluation can tell us if they are well designed and effectively delivered to governments. The present list highlights some of the major problems that I have encountered in recent work on industrial competitiveness.

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Annex Table 1: Distribution of manufactured exports over technological sub-categories, 1985 & 1995

	Resource based				Low technology				Medium technology						High technology			
	Agro		Other		Textiles/fashion		Other		Automotive		Process		Engineering		Electrical/electronic		Other	
	1985	1995	1985	1995	1985	1995	1985	1995	1985	1995	1985	1995	1985	1995	1985	1995	1985	1995
Hong Kong	1.6%	3.0%	1.6%	2.9%	44.1%	42.5%	18.9%	9.5%	0.0%	0.0%	1.2%	3.4%	17.8%	11.7%	13.5%	23.4%	1.2%	3.6%
Singapore	6.2%	2.7%	37.3%	11.2%	4.0%	2.3%	4.6%	4.8%	0.8%	1.1%	5.6%	4.7%	17.0%	13.5%	20.6%	57.3%	3.9%	2.4%
Korea	1.4%	1.4%	7.2%	9.6%	27.2%	11.6%	14.2%	8.7%	2.3%	9.7%	10.4%	13.4%	24.5%	15.8%	11.3%	27.9%	1.4%	1.9%
Taiwan	2.5%	0.9%	7.4%	4.4%	29.5%	12.9%	23.4%	17.1%	3.0%	4.1%	5.5%	8.8%	12.4%	14.6%	15.3%	35.9%	0.9%	1.3%
Malaysia	44.0%	11.1%	9.7%	6.9%	5.4%	5.1%	2.6%	6.1%	0.2%	0.6%	3.0%	4.8%	8.1%	14.4%	25.1%	48.3%	1.8%	2.7%
Indonesia	18.4%	12.2%	56.8%	31.9%	13.1%	20.6%	2.4%	9.8%	0.0%	1.1%	5.8%	8.4%	0.6%	6.6%	2.1%	8.5%	0.9%	1.0%
Philippines	27.2%	6.2%	12.4%	3.3%	10.3%	8.3%	6.8%	4.7%	0.6%	1.8%	4.8%	1.6%	1.0%	5.1%	36.6%	68.6%	0.3%	0.3%
Thailand	24.9%	10.0%	13.0%	9.3%	26.8%	15.2%	8.6%	10.2%	0.4%	2.3%	7.9%	5.4%	13.7%	12.8%	4.0%	32.6%	0.7%	2.2%
China	9.1%	3.5%	29.7%	7.5%	36.7%	33.9%	7.1%	17.9%	0.5%	1.0%	9.7%	6.8%	2.0%	12.0%	0.6%	14.8%	4.6%	2.6%
India	2.8%	1.8%	37.8%	28.4%	40.9%	38.6%	4.4%	10.1%	1.9%	2.8%	2.8%	7.0%	5.4%	4.7%	1.6%	2.7%	2.5%	3.9%
Argentina	36.9%	29.2%	23.3%	12.6%	10.8%	11.3%	5.5%	6.0%	2.4%	18.9%	9.1%	9.9%	7.5%	7.8%	3.7%	1.9%	0.7%	2.5%
Brazil	16.6%	17.1%	27.4%	20.9%	11.6%	9.4%	9.7%	7.3%	7.3%	11.6%	11.8%	12.9%	10.7%	14.2%	3.3%	3.7%	1.6%	2.9%
Mexico	3.6%	2.8%	17.5%	4.5%	5.2%	8.9%	8.0%	10.8%	9.2%	18.8%	5.0%	5.5%	29.0%	20.9%	20.8%	25.5%	1.7%	2.2%
Turkey	7.4%	9.9%	14.4%	7.0%	36.9%	43.9%	16.2%	13.0%	1.8%	2.9%	13.0%	10.1%	8.7%	8.3%	1.1%	3.5%	0.5%	1.3%
Egypt	3.9%	2.7%	58.1%	47.6%	34.0%	30.6%	1.2%	8.7%	0.0%	1.0%	1.5%	5.4%	0.2%	1.7%	0.1%	0.2%	1.0%	2.1%
South Africa	10.8%	9.9%	42.6%	39.9%	5.3%	4.3%	11.2%	12.8%	1.1%	4.8%	17.6%	12.6%	2.4%	9.5%	0.8%	3.0%	8.2%	3.0%
East Asia	*8.2%*	*4.1%*	*14.8%*	*7.8%*	*24.7%*	*16.8%*	*13.6%*	*12.5%*	*1.5%*	*3.0%*	*6.2%*	*8.4%*	*15.3%*	*13.9%*	*13.9%*	*31.5%*	*1.8%*	*1.9%*
South Asia	*4.5%*	*3.1%*	*27.8%*	*22.0%*	*51.8%*	*51.1%*	*4.0%*	*7.6%*	*1.3%*	*2.5%*	*3.4%*	*6.6%*	*4.5%*	*3.0%*	*1.1%*	*1.9%*	*1.7%*	*2.3%*
LAC	*15.5%*	*13.2%*	*43.8%*	*19.0%*	*9.1%*	*9.3%*	*7.8%*	*9.1%*	*4.1%*	*11.4%*	*9.4%*	*9.7%*	*6.8%*	*14.9%*	*2.5%*	*11.5%*	*1.1%*	*1.8%*
MENA	7.6%	6.5%	62.7%	30.2%	12.3%	28.9%	2.2%	9.0%	4.7%	2.8%	5.8%	12.8%	2.9%	5.3%	0.8%	3.3%	0.9%	1.1%
SSA 1	35.5%	25.8%	29.2%	15.0%	13.6%	34.3%	5.7%	10.0%	0.5%	0.5%	11.5%	9.8%	2.5%	2.7%	0.5%	0.5%	1.1%	1.4%
SSA 2	18.5%	12.9%	38.4%	35.3%	7.8%	9.9%	9.5%	12.3%	0.9%	4.0%	15.7%	12.1%	2.5%	8.3%	0.7%	2.5%	6.0%	2.7%
Developing countries	9.8%	5.9%	24.3%	11.7%	21.7%	17.8%	11.2%	12.1%	2.1%	4.4%	7.0%	9.2%	11.9%	13.6%	10.3%	23.5%	1.8%	1.9%
Industrial countries	6.1%	6.1%	13.8%	11.8%	6.0%	5.3%	10.3%	10.6%	14.9%	13.4%	10.5%	9.7%	19.5%	20.7%	11.5%	15.6%	7.2%	6.8%
World	6.7%	6.0%	15.4%	11.8%	8.5%	8.4%	10.5%	11.0%	13.0%	11.2%	10.0%	9.6%	18.3%	18.9%	11.3%	17.6%	6.3%	5.6%

	Annex Table 2: Skill Indices, Technical Enrolments and R&D						
	Countries	Harbison Myers Index	Technical enrolment index	Technical enrolment % population	Engineering enrolment index	Enterprise financed R&D%GNP	Per Capita GNP (1995) $
1	Canada	62.05	103.02	0.692%	86.01	0.81	19,380
2	Australia	50.55	112.70	1.174%	84.29	0.78	18,720
3	USA	50.25	88.10	0.682%	68.98	1.49	26,980
4	Finland	45.05	106.72	1.332%	84.20	1.44	20,580
5	New Zealand	40.80	80.01	0.680%	58.38	0.37	14,340
6	Belgium	38.95	53.36	0.431%	44.03	1.10	24,710
7	Norway	38.85	73.52	0.672%	60.25	0.89	31,250
8	Netherlands	38.35	62.39	0.560%	53.80	0.94	24,000
9	UK	37.55	68.69	0.749%	49.83	1.14	18,700
10	Korea, Republic of	36.10	132.06	1.650%	113.83	2.35	9,700
11	France	35.90	66.39	0.611%	40.22	1.17	24,990
12	Spain	34.85	86.95	0.968%	64.41	0.36	13,580
13	Sweden	34.45	64.50	0.730%	49.94	2.14	23,750
14	Denmark	34.30	62.57	0.601%	49.93	0.95	29,890
15	Austria	32.80	68.24	0.783%	47.11	0.74	26,890
16	Germany	31.65	64.87	0.773%	49.00	1.47	27,510
17	Belarus	30.70	53.59	0.466%	53.35	0.65	2,070
18	Russian Federation	30.15	87.94	1.158%	77.59		2,240
19	Japan	30.05	63.54	0.644%	63.54	2.37	39,640
20	Ireland	29.90	79.58	0.905%	51.24	0.89	14,710
21	Ukraine	29.40	65.91	0.723%	65.91	0.60	1,630
22	Italy	29.10	63.14	0.636%	49.26	0.48	19,020
23	Greece	28.55	64.22	0.717%	50.55	0.12	8,210
24	Israel	28.35	69.74	0.675%	56.98	0.82	15,920
25	Taiwan Province	27.80	82.33	1.065%	70.79	0.99	11,500
26	Estonia	27.65	57.93	0.625%	51.88	0.08	2,860
27	Bulgaria	27.50	62.73	0.666%	57.68	0.49	1,330
28	Portugal	27.20	66.63	0.732%	55.43	0.11	9,740
29	Argentina	26.75	54.10	0.467%	44.08		8,030
30	Slovenia	25.05	49.35	0.509%	45.97	0.77	8,200
31	Switzerland	25.00	46.19	0.511%	36.14	1.89	40,630
32	Poland	23.30	39.07	0.394%	34.94	0.22	2,790
33	Singapore	23.05	48.81	0.472%	44.76	0.69	26,730
34	Peru	22.55	55.11	0.460%	49.63		2,310
35	Lithuania	22.50	40.18	0.399%	36.56		1,900
36	Croatia	22.35	44.93	0.515%	42.82	0.23	3,250
37	Uruguay	21.85	35.84	0.289%	34.27		5,170
38	Lebanon	21.60	46.89	0.395%	34.60		2,660
39	Philippines	21.60	54.57	0.551%	43.65	0.05	1,050
40	Latvia	21.35	34.35	0.339%	27.64	0.10	2,270
41	Chile	21.00	62.11	0.726%	59.01		4,160
42	Costa Rica	20.95	43.02	0.345%	36.45	0.00	2,610
43	Moldova	20.50	37.35	0.352%	37.01	0.01	920
44	Panama	20.20	58.84	0.593%	52.19	0.00	2,750
45	Czech Republic	20.00	40.62	0.464%	37.21	0.76	3,870
46	Slovakia	19.20	51.35	0.684%	47.70	0.60	2,950

47	Kuwait	19.10	36.49	0.390%	30.57		17,390
48	Jordan	18.55	39.27	0.417%	27.64		1,510
49	Hong Kong	18.45	40.41	0.490%	29.46	0.01	22,990
50	Hungary	17.65	23.47	0.163%	21.69	0.31	4,120
51	South Africa	17.05	23.61	0.174%	17.32	0.38	3,160
52	Yugoslavia	17.05	57.76	0.517%	52.39		2,500
53	Romania	16.95	39.33	0.490%	34.30	0.16	1,480
54	Egypt	16.45	16.10	0.120%	13.87		790
55	Thailand	15.55	30.25	0.186%	25.99	0.01	2,740
56	Colombia	15.30	43.55	0.511%	41.79		1,910
57	Ecuador	15.00	32.29	0.285%	29.01		1,390
58	Bolivia	14.80	31.90	0.343%	26.30		800
59	Turkey	14.70	35.66	0.327%	30.35	0.20	2,780
60	Yugo. Macedonia	14.45	35.06	0.427%	29.96		1,500
61	Cuba	14.35	20.55	0.188%	19.09	0.00	1,500
62	Iran	14.30	37.58	0.445%	30.03	0.00	2,000
63	Mongolia	13.50	30.29	0.292%	26.03	0.00	310
64	Saudi Arabia	13.45	18.96	0.123%	14.42		7,040
65	Syria	13.35	23.47	0.196%	17.67		1,120
66	Mexico	12.95	37.53	0.439%	31.83	0.04	3,320
67	Tunisia	12.55	24.49	0.239%	16.15	0.24	1,820
68	United Arab Emir.	12.20	7.51	0.054%	5.70		17,400
69	El Salvador	12.05	33.56	0.265%	31.53	0.00	1,610
70	Algeria	11.65	31.14	0.410%	21.55		1,600
71	Malaysia	11.10	15.98	0.130%	12.65	0.17	3,890
72	Trinidad & Tobago	11.05	13.36	0.140%	10.26		3,770
73	Indonesia	10.35	22.98	0.226%	19.11	0.08	980
74	Namibia	10.25	8.98	0.033%	7.36		2,000
75	Brazil	10.15	19.87	0.182%	15.50		3,640
76	Sri Lanka	10.05	7.79	0.085%	5.45	0.00	700
77	China	9.75	9.85	0.101%	8.75		620
78	Jamaica	9.60	12.12	0.113%	8.47		1,510
79	Morocco	9.55	23.73	0.253%	11.46		1,110
80	Nicaragua	9.40	19.57	0.218%	15.69	0.00	380
81	Mauritius	9.35	7.16	0.045%	6.27	0.01	3,380
82	Oman	8.95	5.35	0.041%	4.44		4,820
83	Paraguay	8.95	14.54	0.114%	10.71		1,690
84	Albania	8.30	14.54	0.112%	12.92		670
85	Honduras	8.20	19.56	0.200%	17.00		600
86	Zimbabwe	8.15	8.41	0.087%	7.07		540
87	India	8.10	11.85	0.117%	7.18	0.12	340
88	Congo	7.95	7.54	0.044%	5.32		680
89	Botswana	7.65	7.31	0.076%	3.52		3,020
90	Nepal	6.40	8.51	0.075%	5.22		200
91	Myanmar	5.90	15.39	0.199%	6.06		350
92	Nigeria	5.05	5.85	0.057%	3.99	0.00	260
93	Cote d'Ivoire	4.50	8.34	0.092%	4.43		660
94	Yemen	4.45	4.60	0.021%	4.17		260
95	Ghana	4.40	1.16	0.012%	0.76		250
96	Cameroon	4.35	5.70	0.064%	2.82		650
97	Togo	4.30	4.21	0.029%	2.99		310

98	Bangladesh	4.30	7.66	0.075%	4.15		240
99	Pakistan	4.10	5.06	0.052%	3.98	0.00	460
100	Lesotho	4.00	3.53	0.027%	2.42		770
101	Mauritania	3.55	5.28	0.031%	3.74		460
102	Senegal	3.30	5.55	0.053%	3.14		600
103	Laos	3.25	2.19	0.018%	1.88		350
104	Kenya	3.20	2.00	0.017%	1.34		280
105	Madagascar	3.10	5.96	0.062%	3.27	0.00	230
106	Afghanistan	3.10	1.67	0.009%	1.36		120
107	PNG	3.00	4.23	0.021%	3.88		1,160
108	Benin	2.90	3.95	0.038%	2.53		370
109	Sudan	2.80	3.50	0.025%	2.92		120
110	Eritrea	2.45	1.92	0.019%	0.98		100
111	Uganda	1.95	2.06	0.013%	1.78		240
112	CAR	1.70	1.74	0.012%	1.44		340
113	Ethiopia	1.45	1.16	0.012%	0.90		100
114	Burkina Faso	1.35	1.71	0.016%	0.91		230
115	Mali	1.30	0.97	0.007%	0.90		250
116	Chad	1.30	0.92	0.007%	0.61		180
117	Burundi	1.15	1.38	0.013%	0.76		160
118	Malawi	1.00	1.17	0.008%	1.01		170
119	Mozambique	0.90	1.07	0.013%	0.72		80
120	Tanzania	0.75	1.03	0.012%	0.88		120

Source: Calculated from UNESCO and World Bank data.
Technical enrolment index is tertiary total enrolment (times 1000) plus tertiary enrolment in technical subjects (times 5000), both as % of population.
Engineering skills index is same as pervious index, with tertiary enrolments in engineering instead of enrolments in all technical subjects.