RETHINKING DEVELOPMENT ECONOMICS

Edited by
Ha-Joon Chang

TE 370 .99

12 CÓPIAS

13

TECHNOLOGY AND INDUSTRIAL DEVELOPMENT IN AN ERA OF GLOBALIZATION

Sanjaya Lall

1. Introduction

Technical progress, liberalization and the spread of globalized production systems are creating new opportunities and challenges for industrializing countries. There are, however, different perspectives on how they affect the Third World. The optimistic view is as follows. Technology is now more mobile internationally. Information is easier to access and the cost of transmitting it has fallen to very low levels. TNCs (transnational corporations), the main creators of technology, are constantly searching for new sites in which to use this technology and so are transmitting it more widely. Older technologies are readily available from smaller companies. Countries are eager to attract technology and foreign investment, particularly into export activities, and are removing barriers to imports of equipment and information. Thus, technology will flow to poor countries as they open up to trade and investment: all they need to do is to liberalize, create 'market friendly' environments and invest in infrastructure and education.

There is a less sanguine view, based on four features of technology, to which this chapter subscribes. First, new technologies are not simply 'transferred' to poor countries and used efficiently by them in response to market forces. Considerable effort is needed to access, master, adapt and use them at competitive levels. Thus, while greater openness to technologies and trade is desirable for most of the developing countries that have pursued strongly inward-oriented policies in the past, full and rapid exposure to world markets may not be beneficial. When markets suffer from diffuse failures,[1] liberalization can be costly and damaging, and needs to be carefully managed to conserve and improve domestic capabilities. This calls for government strategy and intervention, but the liberalization that accompanies globalization constrains the freedom of governments to intervene.

Second, technologies are improving in terms of their skill, technology and organizational demands, making the development of capabilities more difficult for new entrants. The newest industrial entrants are disadvantaged, in that capabilities develop cumulatively, so that countries with a head start can pull further away. There may thus be growing divergence, even within the developing world, between countries that have launched effective learning and those that have not.[2] 'Cumulativeness' and 'path-dependence' are ominous terms for latecomers that have not yet mounted effective technology strategies.

Third, the growth of integrated production systems, with facilities at different levels of technological complexity spread over countries, reduces the need for building local capabilities in low-wage countries. However, given economies of scale and cumulative learning, production systems are likely to concentrate in a few sites. There are likely to emerge a few major centres in each region with core industrial activities – say, one or two each in Latin America, East Asia, South Asia, Sub Saharan Africa and the Middle East – and countries outside these centres are likely to be increasingly marginal to production and related activities. In a world of shrinking economic distance and fewer barriers to trade and investment, global production systems are likely to be increasingly inequitably spread.[3]

Fourth, economies of agglomeration exacerbate the inequitable spread of global production. As 'new economic geography'[4] shows, cluster economies are important determinants of industrial location. These economies raise the threat of divergence.

Thus, while the mobility of knowledge and production makes it theoretically easier for all countries to access technologies and markets, it does not mean that all countries will benefit. On the contrary, there are inexorable technological forces making for divergence, not just between developed and developing countries, but also between first movers and laggards in the developing world. The pressures for liberalization that accompany globalization make it more difficult for the laggards to catch up, and this is the issue explored in this essay.

2. The Emerging Setting

The structural changes noted above are not really new. What is new today is their pace and spread, creating a qualitatively different setting for industrial activity compared to the time when most developing countries launched industrial strategies, or to the early twentieth century when the world was

relatively open. The information revolution and falling transport costs have brought economies much closer. Technical change is more rapid and pervasive by activity and location. Its nature is different, as are its (tighter) links to the education and science base. Its diffusion now takes place through different mechanisms, and more stringent property rights protect it.

Technology intensive activities, with high rates of R&D spending, are growing much faster than others.[5] We examine their export performance by looking at different technological categories.[6] We separate primary products from manufactures, dividing the latter into four: resource-based (RB), low technology (LT), medium technology (MT) and high technology (HT). In broad terms, resource-based and low technology can be regarded as technologically 'simple', and 'medium' and high technology as 'complex'. Table 1 shows the growth rates of exports in the period 1985–2000 in these categories.

The salient points are as follows:

- Manufactured products are the engine of global export expansion, growing nearly three times faster than primary products.
- Within the main groups of manufactures, RB products grow the slowest and HT the fastest for all groups of countries. Products with 'natural' advantages (i.e. primary and RB manufactures together) are not dynamic; their combined share declined from 43% to 26% over the period 1985–98. HT products are the most dynamic, while LT and MT products grew at almost the same pace.

Table 1. **Structure and growth of world exports, 1985–2000 ($ (in millions) and %)**

Products	1985	2000	Annual growth rate	Distribution 1985	Distribution 2000
All sectors	1,703,582,494	5,534,008,649	8.17	100	100
Primary Products	394,190,554	684,751,141	3.75	23.1	12.4
Manufactures	1,252,573,675	4,620,266,770	9.09	73.5	83.5
Resource based	330,863,869	863,503,545	6.60	19.4	15.6
Low Technology	241,796,065	862,998,972	8.85	14.2	15.6
Medium Technology	485,784,011	1,639,871,870	8.45	28.5	29.6
High Technology	198,029,682	1,269,587,194	13.19	11.6	22.9
(of which, ICT)	90,151,843	773,119,244	15.40	5.3	14.0

Source: Calculations based on UN Comtrade database, using classification developed by Lall 2001.

- In terms of value, MT products remain the largest category in manufactured exports, with about 1/3 of the total, but at current rates of growth HT products (now at over 1/5 of the total) will soon overtake them. The 'complex' categories (MT and HT) comprise 54% of total world and 64% of manufactured exports in 1998.
- Developing countries grew slower than developed countries in primary exports and RB manufactures. However, they grew faster in manufacturing as a whole and in most technological subcategories apart from RB. What is more interesting is that their growth lead over developed countries rose with technological intensity.

This picture is intriguing. While the HT group is the most dynamic, growth rates do not rise uniformly with technological sophistication. Technology is not, in other words, the only 'driver' of trade dynamism, though it is a powerful force in export growth. The other important driver is the relocation of production (of labour-intensive processes) from rich to poor countries. The relocation has gathered momentum recently because of falling transport costs, trade liberalization and the aggressive search by some developing countries for export-processing FDI. To the extent that it is a once-and-for-all adjustment, however, the trade dynamism it engenders is likely to weaken. Long-term dynamism is expected to depend on such factors as demand growth, innovation and substitution – all strongly related to innovation.

Consider now distribution of manufactured exports by developing countries (Table 2). East Asia dominates all manufactured exports and all categories apart from resource-based products. Its share is growing in all categories except for LT; in HT, it commands over 85%. The other outstanding performer is Mexico, with NAFTA driving rapid export growth in all categories; the rest of Latin America does rather poorly despite massive liberalization. Sub Saharan Africa is practically absent, with the minor exception of RB products, but even in this category it has a tiny presence relative to its strong resource base. Again, such liberalization that has taken place has done nothing to its export dynamism.

Exports in the developing world are also concentrated nationally. The largest 10 exporters account for over 80% of total manufactured exports, their dominance rising over time:[8]

- Overall concentration is very high: in 1998, 5 countries accounted for 60% and 10 for over 80% of total manufactured exports by developing countries.
- Concentration rises with technological sophistication, reaching 96% for the leading 10 HT exporters in 1998.
- Concentration tends to rise over time. This suggests that entry barriers are rising: the ability to compete is not growing in response to liberalization.

***Table 2*: Regional shares of developing countries' manufactured exports**
(% of developing world total)[7]

	Year	East Asia	South Asia	Middle East, North Africa	Latin America incl. Mexico	Latin America excl. Mexico	Mexico	Africa incl. South Africa	Africa excl. South Africa
All	1985	56.9	4.5	12.9	23.1	16.9	6.2	N/A	2.6
Manufactures	1998	69.0	3.8	6.0	19.3	8.9	10.4	1.8	0.8
RB	1985	34.6	3.8	23.8	32.9	30.7	2.2	N/A	4.9
	1998	47.5	4.7	15.0	28.0	24.0	4.0	4.8	1.4
LT	1985	71.7	8.3	7.3	11.9	10.2	1.7	N/A	1.8
	1998	70.2	8.5	7.2	12.6	5.4	7.2	1.5	0.2
MT	1985	63.4	2.0	7.1	25.8	17.5	8.3	N/A	1.8
	1998	63.8	1.8	4.4	28.1	10.2	17.9	1.9	0.2
HT	1985	81.0	1.1	1.8	14.8	6.6	8.2	N/A	1.3
	1998	85.5	0.6	0.7	12.9	2.1	10.8	0.4	0.0

Source: Lall 2001.

Note: 'Africa' denotes Sub Saharan Africa only.

This uneven distribution cannot be explained by differences in trade or investment policies, and it cannot be reversed by persisting with liberalization. It is based on evolutionary processes of building industrial capabilities, and the structural factors involved are difficult to change. Liberalization does not have any in-built forces to reverse cumulative causation.

Trade is also concentrated at the enterprise level, with a relatively small number of firms dominating in most industries. Of these, TNCs are the dominant force, accounting for around 2/3 of world trade.[9] The role of giant firms from the mature industrial countries is particularly large in products with significant economies of scale in production, marketing and innovation. Of the visible trade handled by TNCs, around 1/3 is within TNC systems, between affiliates and parents, or among affiliates. Such internalized trade contains the most dynamic form of exports today: integrated international production systems, in which TNCs locate different functions or stages of production in different countries and link them tightly together.

Affiliates participating in such systems tend to produce on a massive scale (thereby realizing enormous economies of scale) and use the latest technologies, skills and managerial techniques. However, other global industries (now commonly called 'global value chains') are also more tightly organized than before. Even in the field of low technology activities, where FDI is not important (clothing is a good example), there are a few lead players that manage production and marketing; many are international buyers without significant overseas direct investment.

Large companies with transnational operations also increasingly dominate *innovation*: the creation of new technologies and organizational methods that drives competitiveness in all but the simplest activities. Despite innovation by smaller enterprises in new information-based industries, large TNCs account for growing shares of business-funded R&D spending in mature industrial countries. About 90% of world R&D expenditure is in the OECD countries. Within this group, seven countries (led by the USA) account for 90% of R&D, the USA alone for 40%.[10] In the USA, just 50 firms (of a total of over 41,000) account for nearly half of industry-funded R&D.[11] Access to new technologies thus involves access to the knowledge and skills of these leaders, which are increasingly unwilling to part with their most valuable technologies without a substantial equity stake. Thus, FDI becomes the most important – often the only – way of obtaining cutting-edge technologies.

FDI has become a major driver of export competitiveness. In the developing world, the highest shares of affiliates in manufactured exports are in Singapore, Malaysia and Philippines (over 70% each), but TNCs also account for substantial shares in Thailand, Indonesia and China (50% or more). In Latin America, foreign affiliates account for 38% of exports by Argentina and 37% by Mexico (although the foreign share of manufactured exports in Mexico is much higher, given the TNCs' dominant role in *maquiladora* exports).

However, FDI is highly concentrated. At the regional level, South and East Asia and Latin America together account for 93% of total FDI flows to developing countries. The 43 least developed countries receive only half of 1% in the period, and their share does not increase over time. By contrast, the 10 leading host countries raise their shares over the period from 64 to 76%, with Asia and Latin America attracting most inflows to the developing world.

3. Technology in developing countries

Developing countries do not 'innovate' in the sense of creating new products or processes. They do invest in technological effort, but this involves acquiring, mastering and improving upon existing technologies rather than shifting

the frontiers of knowledge. In fact, they often have to undertake greater effort than their counterparts in advanced economies, because their absorptive capacities are much lower. Absorbing technologies is not a trivial or costless task, and industrial success depends on how well the process is managed. Since all countries have access to the same international technical knowledge, a critical determinant of industrial performance is technological 'learning' by different countries. The understanding of this phenomenon is critical to the argument of this chapter.

This is not how received economic theory depicts technology in developing countries. By contrast, it assumes that firms in developing countries operate with full knowledge of all technologies: they are on a universal, well-specified and well-behaved production function. Given the right market prices for inputs and outputs, they pick the technologies appropriate to national factor endowments. By definition, all firms in an industry facing the same prices choose the same technologies. There are no tacit elements in the transfer, no learning costs and no need to adapt. All firms immediately use technologies with the same efficiency. Technical inefficiency *must* be due to managerial slack or incompetence, since there are no learning costs.

According to this argument, there is no meaningful technological activity in countries that use existing knowledge. There is, at most, a simple learning process: costs decline as a new plant is 'run in' and productivity rises from repetitive production. Such processes are relatively trivial, predictable and similar across industries. The learning process is passive, and does not involve investment, risk or long maturation periods. There is no need to build the capability to use new technology, or to distinguish between industries in learning.

Firms are believed to acquire and use technologies as individual units, essentially in isolation. There are no linkages between them, and no externalities resulting from individual efforts to generate skills and information. The development of specialization among firms and industries relies solely on information exchanged in anonymous market transactions. The setting for technology acquisition and deployment has no historical, institutional or social context and is the same everywhere. Since there are no technological externalities, there is also no need to coordinate investments across activities in the same locality or value chain. Nor are some sets of activities more significant for industrial development than others: none offers greater or more beneficial externalities and learning potential does not differ.

Where learning exists, firms are assumed to have the information and foresight to finance the (predictable) process by borrowing in capital markets. If capital markets are not fully efficient, infant industry protection may be a second-best measure. However, any protection must be moderate and uniform across activities to minimize resource misallocation. Since no technologies are more difficult, or involve more externalities, than others, there is no need to be selective in promoting particular industries. There is also no need for different policies by countries at different levels of development. A uniform approach across countries, as well as within them, is the least distortionary.

In this framework, the evolution of competitive advantage depends on the accumulation of factors rather than the building of new capabilities. As endowments grow, firms automatically and costlessly shift across technologies. There is no need for policy to dynamize competitive advantage. 'Getting prices right' is necessary and sufficient to promote development.

A large body of research suggests that this picture is wrong and misleading.[12] While technological hardware (equipment) is available to all countries, the disembodied elements of technology are not transferred like physical products. Technical knowledge is difficult to locate, price and evaluate. Its transfer cannot be embodied in equipment or instructions, designs or blueprints. Unlike the sale of goods, in which transactions are complete when physical delivery has taken place, the successful transfer of technology is a prolonged process, involving local learning to complete the transaction. The embodied elements can be used at best practice levels only if they are complemented by a number of *tacit* elements that must be developed locally.

The need for learning exists in all cases, even when the seller of the technology provides assistance, though the costs vary by technology, firm and country.[13] Learning calls for conscious, purposive efforts – to collect new information, 'try things out', create new skills and operational routines and strike new external relationships.[14] This process has to be located at the production facility and embodied in the institutional setting of the enterprise. This process is strikingly different from textbook depictions of technology transfer. We will summarize the ten most important features of technology capability development.[15]

First, learning is a real and significant process. It is vital to industrial development, and is primarily conscious and purposive rather than automatic and passive.

Second, firms do not have full information on technical alternatives; rather, they function with imperfect, variable and rather hazy knowledge of technologies. There is no uniform, predictable learning curve: each firm has a unique learning path depending on its initial situation and subsequent efforts. Each faces risk, uncertainty and additional cost in learning. Differences between learning are larger between firms in countries at differing levels of development.

Third, firms may not know how to build up the necessary capabilities – learning itself has to be learned. Enterprises may not be able to predict if, when, how and at what cost they learn enough to become competitive, even where the technology is well known elsewhere. This adds to the uncertainty of learning.

Fourth, firms cope not by maximizing a well-defined objective function but by developing organizational and managerial satisfying 'routines', which they adapt over time as they collect new information, learn from experience and imitate other firms.[16] Thus, learning tends to be 'path dependent' and cumulative. Once embarked on, technological trajectories are difficult to change suddenly, and patterns of specialization persist over long periods.

Fifth, the learning process is technology specific. Some technologies are more embodied in equipment while others have greater tacit elements. Process technologies (like chemicals) are more embodied than engineering technologies (machinery or electronics), and demand different (often less) effort. Different technologies involve different learning costs, risks and duration, and differ in their linkages: there are 'easy' and 'difficult' technologies (garment assembly is 'easier' than textile manufacture, which is 'easier' than making textile machinery). Capabilities in one activity may not be easily transferable to another, and policies to promote learning in one may not be very useful in another. Different technologies involve different breadth of skills and knowledge, some needing a narrow range of specialization and others a wide range.

Sixth, different technologies have different degrees of interaction with outside sources of knowledge (firms, consultants, equipment suppliers or technological institutions). These differences lead to different costs, risks and duration.

Seventh, capability building involves effort at all levels: procurement, production, process or product engineering, quality management, maintenance, inventory control, outbound logistics, marketing and external links. 'Innovation' in terms of formal R&D is at one end of the spectrum of technological activity. It does not exhaust it. Most learning in developing countries arises in mundane technical activities, but formal R&D becomes important in complex technologies where efficient absorption requires experimentation.

Eighth, technological development can take place to different 'depths'. The deeper the levels of technological capabilities, the higher the cost, risk and duration involved. It is possible for an enterprise to become, and remain, a good user of imported technologies without developing the ability to 'decode' the processes in order to significantly adapt, improve or reproduce them, or to create new products or processes. This is not optimal for long-term capability development. Without technological deepening, the enterprise or country remains dependent on external sources for major expansion or improvement to its technologies – a costly and possibly inefficient outcome.

Ninth, enterprise technological learning does not take place in isolation: it is rife with externalities and interlinkages. The most important interactions are those between suppliers of inputs or capital goods, competitors, customers, consultants and technology suppliers. Linkages also occur between firms in unrelated industries, technology institutes, extension services and universities, industry associations and training institutions. Many linkages are informal and not mediated by markets. Not all are deliberate or cooperative: some involve imitating and stealing knowledge. Where information and skill flows cohere around a set of related activities, 'clusters' of industries emerge, with collective learning in the group.

Finally, technological interactions occur within and across countries. Imported technology provides a vital initial input into learning in developing countries. Since technologies change constantly, moreover, access to foreign sources of innovation remains crucial to technological progress. Technology import is not, however, a substitute for capability development – domestic technological effort and technology imports are largely complementary.

However, not all *modes of technology import* are equally conducive to indigenous learning. Much depends on how the technology is 'packaged' with complementary factors, whether or not it is available from other sources, how fast it is changing, how developed are the local capabilities and the policies adopted to stimulate transfer and deepening. Transfers that are completely internalized within a firm, e.g. from a TNC parent to its affiliate, are efficient means of providing the latest know-how, but slow in building innovative capabilities in host countries.

4. Structural determinants of technology development

The ability of a country to undertake effective technological effort depends on a complex interaction between its incentive system, factor markets and institutions.[17] The interaction is context specific. It reflects national (regional) policies, resources, support institutions, infrastructure, the inherited skill base, business practices, culture and history. Policies on trade, competition and labour, for instance, affect a firm's learning by influencing the signals it receives from the market. The resource base affects the relative cost and benefit of different learning trajectories. Support institutions affect how firms meet the information, skill, finance and other needs that are difficult to satisfy in open markets. Infrastructure determines the cost of operation and interaction with the outside world. The skill base that firms draw upon determines what and how they learn. The social and business setting, the product of past experience and tradition, is also very important: it affects how firms relate to, and cooperate with, each other.

We now consider the main structural determinants of technology development in the Third World, starting with skills. Skills arise from a variety of sources: formal education, vocational training, in-firm training, specialized training outside the firm and learning on the job. The relative importance of these sources varies according to economic structure, the nature of knowledge utilized and the level of development. Basic schooling and literacy may be sufficient to absorb simple industrial technologies. Advanced schooling and tertiary education become important as more complex knowledge is tackled. Sophisticated modern technologies require high levels of numeracy and a broad base of skills on the shopfloor. They also need a high proportion of technical personnel.

It is difficult to compare skill formation across countries. Informal skill creation on the job is difficult to measure. Data on enterprise training are patchy and incomplete. The available data only allow us to compare enrolments across countries for formal education. Even this has problems. Definitions of education levels are not uniform. The quality of education differs greatly, as does the relevance of the curriculum. Enrolment rates do not show differences in completion rates. Nevertheless, enrolment data are available on a comparable basis, and the rates reveal something about the *base* for skill acquisition.

Table 3 shows broad enrolment patterns for the main groups of countries, including developed and transition economies. The regional enrolment rates are simple averages, not weighted by the relevant populations. They show increases in enrolment rates in all regions. They also show large disparities. Sub Saharan Africa lags at all, particularly tertiary, levels of education. The four mature Tiger economies of Asia (Korea, Taiwan, Singapore and Hong Kong) lead the developing world at higher levels, just slightly lagging behind the developed economies. The new Tigers (Malaysia, Indonesia, Thailand and the Philippines), Latin America and Middle East/North Africa are roughly similar in their secondary and tertiary level enrolments, just behind the levels reached in the transition economies. South Asia and China have low levels of tertiary enrolment, but China is considerably stronger at the secondary level. To the extent that these indicators are valid, they show large gaps in the skill base for competitiveness.

The breakdown of tertiary enrolments in technical subjects is more relevant for the assessment of capabilities to absorb technological knowledge and, of these, enrolments in engineering are the most significant. Table 4 shows the total numbers enrolled in tertiary education and in the three main technical subjects (science, mathematics/computing and engineering) by region in 1995, with regional averages weighted by population. The figures show much wider dispersion in skill creation than the general enrolment rates.

Table 3: **Enrolment Ratios**
(percentage of age groups)

Mean for group (unweighted)	Enrolment Ratios (1980)			Enrolment Ratios (1995)		
	1 level	2 level	3 level	1 level	2 level	3 level
Developing countries	**88**	**34**	**7**	**91**	**44**	**11**
Sub Saharan Africa	74	17	1.3	78	23	2.9
MENA	88	42	9.7	92	59	14.3
Latin America	102	45	14.1	103	53	18.1
Asia	95	44	7.4	99	54	14.4
4 Tigers	106	72	13.0	100	82	36.4
4 new Tigers	103	43	12.3	102	60	17.3
S Asia	75	28	4.0	93	42	4.8
China	112	46	1.3	120	69	5.7
Others	96	37	3.7	98	35	5.9
Transition economies	**100**	**77**	**14.6**	**95**	**76**	**22.2**
Developed Economies	**102**	**84**	**27.2**	**104**	**113**	**50.6**
Europe	101	82	24.5	104	113	44.6
N America	101	91	49.1	102	102	92.0
Japan	101	93	30.5	102	99	40.3
Australia/ N Zealand	111	84	27.0	106	132	65.0

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

The Asian NIEs enrol over 33 times the proportion of their population in technical subjects than Sub Saharan Africa (including South Africa). The ratio is twice that of industrial countries, nearly 5 times that of Latin America and the new NIEs, and over 10 times that of South Asia and China.

Much technological effort is informal, consisting of tinkering, improvements, adaptations and copying, rather than formal R&D. Over time, R&D becomes more important as countries use increasingly complex technologies and have to use formal R&D to understand, absorb and adapt such technologies and develop new technologies. The R&D data (Table 5) show the same unevenness as skill formation – unsurprisingly, both are strongly linked. The best measure of industrial technology is productive enterprise financed R&D.[18] As a percentage of GNP, this is nearly 400 times higher in the mature Asian Tigers is than it is in Sub Saharan Africa, and around 10 times higher than in the new NIEs and Latin America.

Table 4: Tertiary level enrolments and enrolments in technical subjects (1995)

	3 level enrolment		Technical enrolments, numbers & % of population							
	Total	% pop.	Natural Science		Maths, 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

Table 5: **R&D propensities and manpower in major country groups**
(simple averages, latest year available)

Countries and regions (a)	Scientists/engineers in R&D		Total R&D (% of GNP)	Sector of performance (%)		Source of Financing (% distribution)		Source of financing (% of GNP)	
	Per million Population	Numbers		Productive sector	Higher education	Productive enterprises	Government	Productive enterprises	Productive sector
Industrialized 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 (excl. South Africa)	83	3,193	0.28	0.0	38.7	0.6	60.9	0.002	0.000
North Africa	423	29,675	0.40	N/A	N/A	N/A	N/A	N/A	N/A
Latin America & Caribbean	339	107,508	0.45	18.2	23.4	9.0	78.0	0.041	0.082
Asia (excluding Japan)	**783**	**893,957**	**0.72**	**32.1**	**25.8**	**33.9**	**57.9**	**0.244**	**0.231**
NIEs (d)	2,121	189,212	1.50	50.1	36.6	51.2	45.8	0.768	0.751
New NIEs (e)	121	18,492	0.20	27.7	15.0	38.7	46.5	0.077	0.055
South 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**

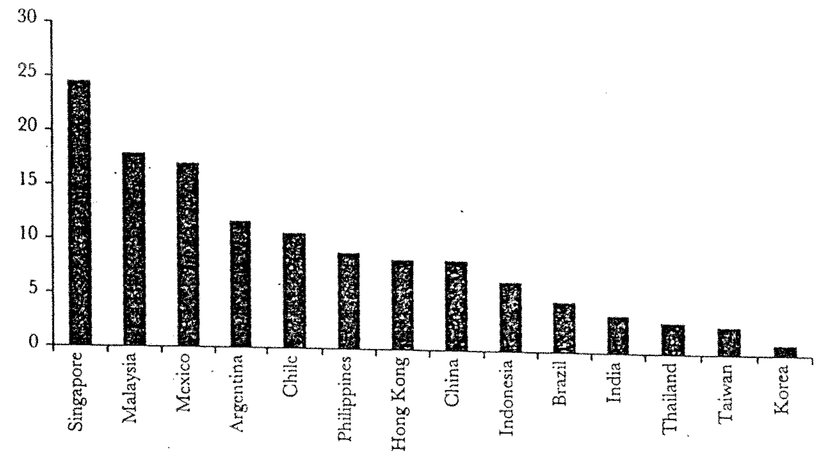
Source: Lall 2001.

Notes: (a) Only including countries with data and with over 1 million inhabitants in 1995. (b) USA, Canada, Western Europe, Japan, Australia and New 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.

These averages conceal large national differences. The leader in the developing world is Korea, which is neck-and-neck with Japan (and is second in the world after Sweden). Taiwan comes next, spending the same proportion as the UK and a higher proportion than the Netherlands or Italy. Singapore follows, with TNC affiliates conducting the bulk of industrial R&D. These three Tigers are in a different class from other developing countries. Some successful exporters (like Mexico, Thailand, Philippines or Indonesia) conduct little R&D and depend heavily on TNCs to provide innovative inputs. This may be viable in the short-term but not in the long-term. Some, like India, have significant industrial R&D, but lag technologically because of obsolete trade strategies or infrastructure problems. Most others, with weak industrial sectors, make little or no technological effort. They risk being caught in a vicious spiral of industrial backwardness, low skills, low FDI inflows and little ability to absorb or improve on modern technologies.

We have remarked on the skewed distribution of FDI. Figure 1 shows FDI as a percentage of gross domestic investment in 1997 (the picture is similar over the longer term). Reliance on FDI differs sharply among the newly-industrializing countries, with very high reliance in Malaysia and Singapore of the East Asian countries, and in most of Latin America. There is low reliance in Korea and Taiwan, which deliberately restricted inward FDI at the critical stage of building local innovative capabilities. This suggests a trade-off between deepening technological capabilities and relying on ready-made technology from TNCs.

Figure 1. **Foreign direct investment as % of gross domestic investment, 1997**



Note that in Latin America, unlike East Asia, much of recent FDI has (with the exceptions of Mexico and Costa Rica) gone into resource-based activities and services, and not into export-oriented manufacturing. Thus, Latin America has not entered dynamic value chains; its lag in electronics is particularly striking. With local firms unable to mount the technological effort to become competitive in hi-tech activities, Latin America now has a low-growth export structure with less spillover and learning benefits from FDI than in East Asia.

We noted the conflict between relying on technology transfers via FDI and developing innovative capabilities. FDI is an effective means of transferring new technologies rapidly and deploying them in production. It is a less effective means of building local capabilities (beyond those needed for production). It is not in the economic interest of TNCs to launch R&D in all affiliates and, where they do start R&D, to go beyond adaptive work in most developing countries. However, host countries have to promote innovation as industrialization continues to take place. It is for this reason that Korea and Taiwan promoted local R&D by restricting FDI.

5. Trade policy for industrial development

Current wisdom eschews trade interventions for industrial development. Its reasoning is based on neoclassical trade theory: free trade promotes the optimal allocation of resources (except when a country has monopoly power in trade). This is based on stringent assumptions, including no scale economies, 'well-behaved' production functions, full information, identical technologies across countries, no learning costs, no risk or uncertainty and so on. All these assumptions are unrealistic and theorists have relaxed several over time. However, perhaps the most unrealistic assumption – and the one most ignored in subsequent refinements – is that there are no capabilities involved in using technologies in developing countries.

The capability approach suggests that free markets cannot give the right signals for resource allocation in the presence of market failures. Free trade leads to latecomers under-investing in 'difficult' technologies, because firms cannot fully recoup their costs when faced with competitors that have already undergone learning or have stronger national learning systems. The market failures arise in encouraging entry into difficult technologies or those with widespread externalities, and in coordinating decisions by numerous enterprises that engage in independent learning but that draw heavily on each other.

On its own, protection does not consitute adequate industrial policy: it will not lead to competitive capabilities if factor markets facing firms are deficient. If the labour market cannot provide the new skills needed, the financial market the capital to finance learning, or the technology market the information needed to master new technologies, protection will result in inefficiency. It is vital to combine protection with improvements in the relevant factor markets – trade policy must be part of a larger strategy.

Intervention to restore efficient allocation must vary by activity according to technology and linkages. Uniform support across activities makes as little sense as non-intervention. However, industrial policy can only work if enterprises take advantage of protection to invest in building capabilities. If they simply collect rents in protected markets they will end up with inadequate capabilities. The secret of effective trade policy lies in combining the sheltering of learning with a stimulus to build capabilities. The best stimulus comes from international competition. It is perfectly possible to combine protection with international competition through the provision of limited protection or the offsetting protection by strong export incentives; indeed, this is exactly what was done by the most successful Asian Tigers.

Trade interventions must be geared to remedying market failures, and should be removed once the failures have been overcome. They should not be the kind of haphazard, open-ended and non-selective protection used by import-substituting regimes. These regimes did not offset the cushion offered by protection with the sharp edge of competition.

Similar arguments apply to the liberalization of protected regimes. Industries set up behind protective barriers are often technically inefficient. The remedy is not to expose them rapidly to international competition. Activities are not 'efficient' or 'inefficient' in some absolute sense; many can be *made* efficient if supported in 'relearning' capabilities. This needs time and support. Liberalization has to be gradual and coordinated with factor market interventions.

All good economists admit the case for trade interventions, but many argue that practical difficulties make them unfeasible. To the committed neoliberal, market failures are always less costly than government failures. While many governments have certainly 'failed' with industrial policy in the past, there is sufficient evidence that this is neither universal nor necessary.

Effective industrial policy *was* mounted successfully in several East Asian economies,[19] as it was earlier by most currently developed countries.[20] Korea started with light industry, but protected, subsidized and intervened in various ways to deepen its industrial structure. It directed (and often subsidized) credit to promote entry into complex technologies. It forced firms to raise local content. It restricted FDI and intervened in the technology transfer process to raise local capabilities. It created giant conglomerates (the *chaebol*) to lead its export and technological push. It guided and promoted R&D and skill formation. It set up a massive technology infrastructure geared to the needs of selected industries. It ignored intellectual property rights to promote copying and reverse engineering.

All these measures constituted a coherent package aimed at the objective of entering difficult industries with significant local integration under national ownership, and with a steady upgrading of innovative capabilities. The same strategic approach guided its liberalization. Korea opened its economy gradually and in a controlled manner, behind a sustained export push that enabled firms to restructure and expand while building the ability to compete in world markets. The opening-up during the 1980s did not result in dislocation or unemployment. It was only much later when Korea adopted the ill-advised policy of premature and rapid financial liberalization that the crash came.

6. Conclusions

Successful industrialization depends vitally on the ability of each country to cope effectively with technical change. Globalization does not reduce the role of local capabilities. On the contrary, it raises it because technical efficiency in each location becomes the final determinant of success. Technical efficiency requires access to new technologies from across the world, but simply exposing value chain to international trade, investment and other flows is not enough. Various measures must be undertaken – by enterprises and by supporting factor markets, institutions and governments – to ensure that knowledge and other resources are used properly.

The evidence reveals growing diversity in the developing world's industrial performance in the face of liberalization and globalization: an unfortunate but intrinsic feature of the new technology-driven economy. Skill development, industrial specialization, enterprise learning and institutional change create cumulative and self-reinforcing processes that promote or retard further learning. Countries set on a pattern with a low technology, low skill and low learning specialization find it increasingly difficult to change course without a concerted shift in a large number of interacting markets and institutions. Economic liberalization may help them to realise their static comparative advantages based on inherited 'endowments' such as natural resources and cheap unskilled labour. However, it may not lead them to develop the more dynamic (skill- and technology-based) advantages needed to sustain growth. Thus, they risk becoming outsiders in a world of rapid technological change, new skill needs and integrated production systems. They may suffer from long-term 'immiserizing' growth, having to export larger amounts of products facing static or declining prices in order to import given amounts of foreign products.

The 'insiders' are the relatively few developing countries that have been able to launch themselves on a high-learning path. The insiders also differ, depending on the strategies adopted. We may distinguish two general strategies: autonomous and FDI dependent.[21] Autonomous strategies – Korea and Taiwan – entail massive industrial policy and accompanying interventions in factor markets and institutions. They lead to rapid development and deepening of indigenous skills and technological capabilities, with the ability to keep abreast of new technologies and become significant global players.

FDI-dependent strategies comprise two sub-strategies, targeted and passive. Targeted strategies – e.g. those in Singapore – also entail considerable industrial policy, but the intensity of interventions is lower than in those with autonomous strategies.[22] The sources of technical change remain largely outside, in the hands of TNCs; for this reason, there is less need to intervene to promote learning in infant industries. However, industrial policy is needed to ensure the development of the relevant skills, capabilities and institutions required to ensure that TNCs keep transferring new technologies and functions.

Passive FDI strategies – as in Malaysia, Thailand or Mexico – involve less industrial policy in export-oriented activities (though there may be intervention in domestic-oriented activity). TNCs are attracted mainly by low wages for unskilled or semi-skilled labour, and good infrastructure, given a conducive macro environment and welcoming policies to FDI. Subsequent dynamism and upgrading does need more intervention, since with rising wages continued growth depends on whether TNCs can be induced to upgrade from simple assembly into more advanced activities with greater local content. The government has to help deepen the local skill and supplier base, and to target FDI. Without such capability development, the initial spurt of growth may peter out. Countries, like Malaysia, that have attracted high-technology assembly activities are better placed than those (like Bangladesh, Mauritius or Sri Lanka) that have only attracted low-technology clothing. High-technology assembly creates a stronger base (with higher sunk costs) than low technology assembly, though it is also vulnerable if skills do not rise *pari passu* with the changing demands of the industry. The 'new Tigers' of East Asia (Malaysia, Thailand and the Philippines) are extremely susceptible to competition from lower-wage China, which offers a more attractive domestic market, highly productive labour and a large supply of technical skills.

Simply opening up to trade and investment flows is not an adequate strategy for countries at the low end of the technology ladder. Stabilization and liberalization can remove the constraints to growth caused by poor macro management, inefficient public enterprises, high entry costs for private enterprises and restrictions on FDI. However, it cannot allow the economy to build more advanced capabilities, to escape a low-level equilibrium trap. Evidence on Kenya, Tanzania, Zimbabwe and Ghana shows that after an initial spurt of growth, liberalizing economies with static capabilities slow down as their initial advantages are exhausted.[23] The spurt that comes from using underutilized capacity as imported inputs and spares become available. As import competition in product markets increases, enterprises find it difficult to cope, closing down or withdrawing into non-traded activities. Without strategic support from the government, they find it difficult to bridge the gap between their skills and capabilities and those needed for international competitiveness. New enterprises find it even more difficult to enter complex activities with even more stringent skill and technology requirements.

There is a danger, therefore, that industrial structures in low-income countries with passive industrial policy regress into simple activities that do not provide a basis for rapid growth. This is one reason why liberalization has had poor results in Sub Saharan Africa. Liberalization has also led to technological regression in many countries of Latin America, with relatively weak growth and competitive performance. These countries often have a large base of capabilities in such industries as food processing and automobile manufacture, but find it difficult to move into dynamic high-tech activities.

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

There is much to welcome in these trends. Many government interventions to promote development have done poorly, and have constrained rather than helped growth and welfare. Giving greater play to market forces will contain many of the inefficiencies and rent seeking inherent in government intervention. However, as noted, simply opening up to market forces does not deal with many structural problems of development. The most successful developing countries in recent economic history (the Asian NIEs) intervened intensively in markets, with many different strategies to build up their competitive capabilities. Their experience suggests that there is a significant role for

government in providing the 'collective goods' needed for sustained development. The issue is not whether, but how, governments should intervene.

In the absence of renewed international support for (new forms of) industrial policy, current global forces will lead to further divergence in industrial and income growth. This will cause intolerable pressures in a world thrust closer together – the same technological forces that are causing structural divergence also lead to more intense social and political interactions. Many policy makers and analysts see that inequities are rising, but so widespread and insidious are the neoliberal arguments that they are unable to understand the structural forces at work. The first step for the development economics profession must be to understand and explain these; the next must be to devise an appropriate policy response.

Notes

1 Stiglitz 1996.
2 UNIDO 2002.
3 Radosevic 1999.
4 Krugman 1995; Venables 1996.
5 NSF 2000.
6 Lall 2001.
7 'East Asia' includes all countries in Asia east of Myanmar, including Myanmar and Vietnam (but not Laos or Cambodia for lack of reported data) and China, and excludes Japan and Central Asian transition countries. 'South Asia' comprises India, Pakistan, Bangladesh, Sri Lanka, Maldives, Nepal and Bhutan. 'MENA' (Middle East and North Africa) includes Afghanistan and Turkey as well as all Arab countries (Sudan is counted under SSA). 'SSA' (Sub Saharan Africa) includes South Africa (SSA1) unless specified (SSA2). 'LAC' (Latin America and the Caribbean) includes Mexico (LAC1) and excludes it (LAC2) when specified.
8 UNIDO 2002.
9 UNCTAD 1999.
10 OECD 1999.
11 NSF 2000.
12 For a recent review see Lall 2001.
13 Ernst et al. 1999.
14 The theoretical antecedents are 'evolutionary' theories developed by Nelson and Winter 1982, and Metcalfe 1995.
15 Lall 2002.
16 Nelson and Winter 1982.
17 Lall 1992.
18 UNIDO 2002.
19 Their interventions were mounted under certain conditions: strong leadership commitment to competitiveness, flexibility in policy making, skilled and insulated bureaucracy, supporting interventions in factor markets, close interaction with industry and exposure to export competition to discipline both firms and the government. On

Korea see Amsden 1989; Chang 1994; Westphal 2002; and on Taiwan see Wade 1990.

20 Chang 2002.

21 Mathews and Cho 2000 provide a fascinating case study of the strategies used by Asian Tigers to build competitive semiconductor industries.

22 Lall 1996.

23 Lall 1999.

References

Amsden, A, 1989, *Asia's Next Giant: South Korea and Late Industrialization*, New York, Oxford University Press.

Chang, H-J, 1994, *The Political Economy of Industrial Policy*, London, Macmillan.

Chang, H-J, 2002, *Kicking Away the Ladder: Development Strategy in Historical Perspective*, London, Anthem Press.

Ernst, D, Ganiatsos, T and Mytelka, L, 1995, eds, *Technological Capabilities and Export Performance: Lessons from East Asia*, Cambridge, Cambridge University Press.

Krugman, P, 1995, *Development, Geography and Economic Theory*, Cambridge, Mass., MIT Press.

Lall, S, 1992, 'Technological capabilities and industrialization', *World Development*, 20(2), pp. 165–86.

——, 1996, *Learning from the Asian Tigers: Studies in Technology and Industrial Policy*, London, Macmillan.

——, 1999, ed., *The Technological Response to Import Liberalization in Sub-Saharan Africa*, London, Macmillan.

——, 2001, *Competitiveness, Technology and Skills*, Cheltenham, Edward Elgar.

Mathews, JA and Cho, DS, 2000, *Tiger Technology: The Creation of a Semiconductor Industry in East Asia*, Cambridge, Cambridge University Press.

Metcalfe, JS, 1995, 'Technology systems and technology policy in an evolutionary framework', *Cambridge Journal of Economics*, 19:1, pp. 25–46.

Nelson, RR and Winter, SJ, 1982, *An Evolutionary Theory of Economic Change*, Cambridge, Mass., Harvard University Press.

NSF, 2000, *Science and Engineering Indicators 2000*, Washington DC, National Science Foundation.

OECD, 1999, *OECD Science, Technology and Industry Scoreboard 1999: Benchmarking Knowledge-Based Economies*, Paris, OECD.

Stiglitz, JE, 1996, 'Some lessons from the East Asian miracle', *The World Bank Research Observer*, 11(2), pp. 151–77.

UNCTAD, 1999, *World Investment Report 1999*, Geneva, UN Conference on Trade and Development.

UNIDO, 2002, *Industrial Development Report 2002/2003*, Vienna, UN Industrial Development Organization.

Venables, AJ, 1996, 'Localization of industry and trade performance', *Oxford Review of Economic Policy*, 12(3), pp. 52–60.

Wade, R, 1990, *Governing the Market*, Princeton, Princeton University Press.

Westphal, LE, 2002, 'Technology strategies for economic development in a fast changing global economy', *Economics of Innovation and New Technology*, 11(4–5), pp. 275–320.

World Bank, 1993, *The East Asian Miracle*, Oxford, Oxford University Press.

World Bank, 1999, *World Development Report 1999*, Washington, DC, World Bank.