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THE INDUSTRIAL TECHNOLOGY SYSTEM IN EGYPT

(BACKGROUND PAPER)

by

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A. 1. INTRODUCTION

Egypt offers an interesting case study in technology policy. It has one of the largest economies in the Arab Middle East. The size of its industrial sector and its stock of entrepreneurs and trained technical manpower can make it an engine of growth in the region. Given its location (and strategic significance), it can become a major exporter of manufactured products to the region and to Europe: a 'Tiger' like the East Asian newly industrialising economies. For many years, Egyptian industrial development has been distorted and suppressed by a pervasive socialist and protectionist industrial regime, which has led to strong orientation to the domestic market, widespread inefficiency and technological backwardness. This is changing: in the past decade, the Egyptian government has started to liberalise the economy, opening it up to market forces and reducing the role of the government in resource allocation. The evidence so far does not, however, suggest that Egypt is emerging as a Middle Eastern 'Tiger'. Part of the reason lies in the halting nature of the liberalization process. Part lies in the low competitive abilities of Egyptian industry, private or public. And part lies in the lack of effective support from the industrial technology system, which is not being upgraded to meet the emerging technological needs of enterprises.

This paper describes this technology system. It deals with its characteristics, the policy environment and the main institutions, and analyses its relevance to industrial competitiveness. It brings in, where relevant, comparisons with technology systems and policies in other countries, and makes policy recommendations for improving technological performance.

B. 2. BACKGROUND TO INDUSTRIAL TECHNOLOGY IN EGYPT

The Egyptian industrial sector has a long history of public sector-led import substitution. Over time, public enterprises have entered a few technologically demanding activities; however, the overall structure of manufacturing remains relatively 'simple'. The share of heavy industry in total manufacturing value-added is low by standards of medium-sized newly industrialising countries.[1] The private industrial sector, constricted under the socialist regime, is largely in technologically simple activities, primarily those with a strong local resource base. The public sector, held back by inefficiency and inability to generate resources, is unable to sustain industrial deepening or technological development.

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[1] According to calculations based on data from UNIDO, *Industry and Development Global Report 1992/93*, in 1990 'heavy' industry accounted for 45% of manufacturing value-added in Egypt, compared to 64% for Malaysia, 64% for Turkey, 66% for Korea or 72% for Japan. However, in contrast to Egypt, most of the 'heavy' industrial activity in countries like Malaysia, Korea and Japan was in the private sector, and most of it operated at world levels of efficiency.

Since liberalisation, large private enterprises in Egypt have enjoyed fairly free access to modern equipment and know-how from the developed countries. In collaboration with foreign firms, they have built up reasonable mastery of the simple technologies they employ, though they have not advanced beyond this to technology improvement or development. However, most of Egyptian industry, comprised of small and medium enterprises (SMEs), has not reached even the level of efficient mastery. Most SMEs continue to use technologies at low levels of technical efficiency, lagging well behind international frontiers of productivity. They generally focus on serving local markets with low price and low quality products, investing little in training or in upgrading process or product technologies.[2] They have little or no design capability and undertake minimal subcontracting for the modern industrial sector, and tend to have little direct contact with foreign technology suppliers. In general, they exhibit none of the frenetic search for new information on methods of improving competitiveness and cutting costs, or of efforts to raise skills and find new markets, that characterise similar firms in the export-oriented economies in East and South East Asia.

Table 1 shows R&D data for a selection of developing countries in comparison with Egypt. The indicators are not ideal. Total R&D as a proportion of GDP is often dominated by government research which covers all sectors (including defence), and may bear little relation to technological effort in the industrial sector. In the absence of internationally comparable data directly on research by industry, the ones most relevant to technological effort by private industry are those on "R&D Financed by Productive Enterprises". Even these are not ideal: they include non-industrial firms, and also public enterprises that conduct R&D that may have

Table 1: R&D Expenditures and Personnel

	Total R&D (% GNP)	R&D by productive enterprises (% GNP)	Scientists/Engineers in R&D (per 10,000 employees)	Scientists/Engineers in R&D (per mill. pop)
Egypt	0.2	0.04 (est.)	15	439
Korea	2.3	1.9	32	1346
Taiwan	1.8	0.6	42	1987
Singapore	0.9	0.2	27	1297
Malaysia	0.8	0.1	N/A.	181
Thailand	0.2	0.03	N/A.	103
Indonesia	0.2	0.02 (est.)	4	183
India	0.9	0.1	4	111
Turkey	0.7	0.5	12	224
Mexico	0.3	0.03	8	217
Argentina	0.6	0.09	16	336
Brazil	0.7	0.1	9	256

Sources: UNESCO, *Statistical Yearbook* (various); Government of Republic of China (Taiwan), *Statistical Yearbook of Republic of China* (1992); submissions by various governments to UNCTAD, Trade and Development Board, 1994; and National Science Foundation, *International Science and Technology Data Update: 1991*, Washington, DC. The figures are for the most recent years available, mostly the late 1980s and early 1990s.

little market relevance; however, this is the nearest that we can get to a cross-country indicator of industrial R&D. Data on scientists and engineers in R&D show the 'intensity' of research effort, but they also tend to be dominated by research in government institutes and universities.

Bearing in mind these deficiencies, the data suggest that Egypt lags considerably in technological effort behind the NIEs of East Asia, and also behind many other countries with sizeable industrial sectors. However, it is at about the same level as "new NIEs" like Thailand and Indonesia, and just behind Mexico (where R&D declined in the late 1980s as the government, the main performer of R&D, cut its role in the economy). The level of Egyptian R&D seems to have stagnated over time, while it has risen in the dynamic Asian economies. Thailand and Indonesia, whose exports have expanded mainly in light labour-intensive industrial products driven largely by foreign investors, have managed to sustain their industrial growth despite low indigenous technological investments. However, both are very conscious that their lack of local technological activity is

[2] World Bank, *Private Sector Development in Egypt: The Status and Challenges*, 1994.

likely to become a constraint as their industrial and export structures upgrade, and both are making strong attempts to expand their R&D bases. Anecdotal evidence from Egyptian enterprises supports the data in the table. There is in fact very little 'real' R&D conducted by enterprises; what is often classified by firms under this heading is quality assurance and production engineering activity. The bulk of industry remains passively dependent on imported technologies and shows little awareness of the need for formal research effort as an absorptive base for new technologies.

C. 3. MANUFACTURED EXPORTS AS INDICATORS OF TECHNOLOGY

Table ..2: Recent Non-Oil Manufactured Exports by Egypt ($ m. & %)

	1991/2	1992/3	1993/4	Annual Growth Rate
Total	1461.1	1167.4	1127.4	-12%
Textiles	575.4	450.9	495.5	-7%
o/w Garments	204.9	182	217.7	3%
Yarn	283.1	203.8	211.5	-14%
Textiles	87.4	65.1	66.3	-13%
Food Products	144.5	100.4	88.2	-22%
Chemicals	237.4	111.1	110.2	-32%
Engg. & Metals	380.6	379	328.6	-7%
Other	123.2	126	104.9	-8%
Source: World Bank (1994).				

The technological status of the Egyptian industrial sector may be gauged by its recent export performance (Table 2). The total value of non-oil manufactured exports came to $1461.1 million in 1991/92, of which the private sector contributed $731 million.[3] These exports fell by 20% in 1992/3, and by a further 3% in 1993/4, a compound rate of decline of 12% per annum. Part of the overall decline was due to the loss of markets in the former Soviet Union; part certainly reflected the competitive weaknesses of Egyptian industry. The largest single exporter in 1991/2, accounting for 24 per cent of private sector exports and 34 per cent of total non-petroleum industrial exports, was the textile and garment industry. However, given the supply of excellent raw material (long staple cotton) and no significant import constraints in major markets, Egypt's performance seems to be particularly poor.[4] The value of Egyptian textile and garment exports, $575 million in 1991/92, compares poorly with comparable exports of $15.1 billion by Korea, $12.2 billion by Taiwan, or $11.9 billion by Hong Kong, or even with relative newcomers like Sri Lanka ($1.1 billion) and Bangladesh (also $1.1 billion), in the same year.[5] In the region, Egypt exports considerably less textiles and garments than Turkey, Morocco or Tunisia, traceable directly to supply side problems of efficiency and competitiveness in the textile industry.

Another indicator of a country's technological capability is exports of engineering products. For Egypt, these came to $180.8 million in 1991/92, declining by 24.2% in 1992/93. This was a small fraction of similar exports by medium-sized countries in East Asia: Thailand, for instance, with a similar sized population, exported $7.1 billion of machinery and equipment in 1992, while Malaysia, with a much smaller population, exported $15.5 billion; both enjoyed significant increases throughout the 1990s. The relatively narrow base of manufactured exports by Egypt, and its lack of competitiveness in high value-added, high skill products such as machinery and consumer durables, is a sign of Egyptian technological weakness.

If manufactured exports are classified into 'high' and 'low skill' products according to wages paid by the relevant industries in the USA, low-skill products turn out to account for around 80 per cent of the total during the 1980s.[6] In Turkey, and Morocco low-skill products also accounted for the bulk of manufactured exports, but their share was considerably lower than in Egypt, and the export values involved were larger. Most East Asian countries also had a higher proportion of high-skill products in the total than Egypt, with the striking

[3] World Bank (1994), Table 28.

[4] World Bank, *Arab Republic of Egypt: Cotton and Textile Sector Study*, 1991, Report No. 9381-EGT.

[5] Data from World Bank, *World Development Report, 1994.*

[6] The use of average wages as an indicator of the skill content of the work force is not ideal, but is common in the empirical trade literature. The classification yielded is intuitively plausible, and accords with what would normally be regarded as skill-intensive and other products. The use of US data is deliberate, to capture the structure of exports by international standards. I am grateful to Fanny Baert for help with the collection and analysis of these data.

exception of Indonesia, which has experienced a dramatic rise in exports of labour-intensive products like garments, footwear and plywood, led by investors from East Asia relocating in search of lower wage; Indonesian low skill exports were of roughly the same value as Egypt's in 1980, but were over 8 times larger by 1990; Indonesian high skill exports were also larger than Egypt's in the latter year.

All these indicators confirm that Egyptian industry has a relatively weak technological status, feeding into poor competitiveness of manufactured exports.

D. 4. THE SKILL BASE FOR TECHNOLOGY

The skill base in Egypt may be assessed from relative enrolment figures at various levels of schooling and higher education (Table 3). These suggest that the country is well-endowed with many of the human capital requirements for industrial technology. In schooling, for instance, Egypt compares well with neighbouring countries and with East Asia. Its performance is especially good at the secondary level, where its enrolment ratio is almost at the level of Korea (and slightly behind the levels reached in developed countries, at around 90 per cent). At the tertiary level, while it is ahead of neighbouring countries and of "new NIEs" like Indonesia and Malaysia, it lags behind technologically dynamic countries like Korea. In terms of enrolments in 'technical fields'[7] at the tertiary level, however, Egypt falls behind all the countries in the sample except for Indonesia, though in engineering by itself, it does better than all the countries except for Turkey and Korea. Since this is the discipline that is most directly relevant to industrial technology, the implication is again that there is currently no quantitative shortage of high-level technical manpower in Egypt.

These enrolment figures may be somewhat misleading, however, as far as the supply of *industrial* skills is concerned. The content and quality of Egyptian tertiary level technical education seem to be unsuited to modern industrial needs.[8] There are, in consequence, serious shortages of middle-level managerial and supervisory personnel. Firms, especially foreign investors, have to use much more expensive expatriate staff, or undertake costly training programmes to remedy deficiencies in the education system. Egypt's large vocational training system also suffers from serious problems of quality and lack of practical orientation or relevance. The shortage of experienced and skilled workers leads to high turnover rates, raising the cost of training to industry and detracting firms from investing in long-term and expensive skill creation. At the same time, the special training needs of industry are not properly met by existing government institutions, whose curricula are not responsive to changing industrial needs.

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[7] Technical fields at the tertiary level include natural science, computer science, mathematics and engineering.

[8] The World Bank notes with respect to engineering education, "..there has generally been a marked deterioration in the quality of studies in most faculties in the context of rapid expansion of enrolments with low levels of public funding. The philosophy of free higher education, especially for an expensive discipline like engineering, has resulted in the development of a network of overcrowded institutions with insufficient financial, physical and human resources to ensure adequate learning conditions...Furthermore, strict adherence to rigid and traditional curriculum requirements of the Supreme Council of Universities and the absence of industrial links have prevented most engineering programmes from adapting their curricula to the changing technological needs of the production sectors. The result is that most engineering graduates, who should be applications-oriented, have almost no practical knowledge of design and applications technology, so that their value and potential contribution to the development of the industrial sector is far less than it might otherwise be." *Staff Appraisal Report: Arab Republic of Egypt, Engineering and Technical Education Project*, October, 1989.

Table 3: Skills for Technology Development										
Country	Numbers enrolled as % of age group						Enrolments in tertiary technical education			
	Primary		Secondary		Tertiary		All Technical Fields		Engineering only	
	1970	1990	1970	1990	1970	1990	Numbers	% of pop.	Numbers	% of pop.
Egypt	72	98	35	82	18	19	66610	0.12	42354	0.08
Turkey	110	110	27	54	6	14	142446	0.26	96633	0.17
Morocco	52	68	13	36	6	10	70933	0.28	2275	0.01
Tunisia	100	116	23	45	5	9	13939	0.17	4792	0.06
Indonesia	72	117	12	45	1	10	137324	0.08	109472	0.06
Malaysia	90	93	28	56	2	7	26026	0.15	12693	0.07
Korea	101	108	35	87	6	39	410929	0.96	249919	0.58

Sources: World Bank, *World Development Report 1993*, UNESCO, *Statistical Yearbook 1992.*

Notes: Technical fields include natural science, mathematics, computing and engineering.
Tertiary level technical enrolments are for most recent year available, mostly for 1990.

This is in contrast to the Asian NIEs, where governments made enormous efforts to involve industry directly in the determination of educational content, and to make education and training responsive to changing technological needs. They also sought to raise in-firm training, one of the most critical inputs into raising levels of technological efficiency. While firm training is left to firm initiative in Egypt and is only undertaken systematically by the largest firms, most Asian NIEs impose training levies on industrial firms to encourage training and subsidise it in smaller enterprises. Malaysia has, for instance, recently started to levy large firms 1 per cent of payroll, while providing a 200 per cent tax deduction to smaller firms for undertaking training. Korea has long had a training levy of 5 per cent on its large firms.

E. 6. Foreign Direct Investment and Technology Transfer

Of the main forms of technology transfer — foreign direct investment (FDI), licensing, and the purchase of equipment — FDI and equipment purchase are the most commonly used by Egyptian industry. FDI is relied upon in industries with relatively complex technologies, while equipment purchase is common in industries where (as in textiles and food processing) the technology is not very advanced and there is an long experience of manufacturing.

Table 4: FDI Inflows into Egypt and Other Developing Countries ($ mill.)

Country	1990	1991	1992
Egypt	253	359	451
China	3487	4366	11156
Singapore	5263	4395	5635
Malaysia	2332	3998	4469
Mexico	2632	4762	5366
Argentina	1836	2439	4179
Thailand	2444	2014	2116
Hong Kong	1728	N/A.	1918
Taiwan	1330	1271	N/A.

Sources: Data provided by the General Authority for Investment, Cairo, and UNCTAD, *World Investment Report 1994*, Table I.5.

FDI has increasingly become the main vehicle for technology transfer to developing countries, as the pace of technological change has accelerated and production has become 'globalised'. However, Egyptian industry has been unable to draw fully upon FDI to upgrade its technology. The amount of inward FDI in Egypt has been relatively low. While the "open door" policy did stimulate foreign investments, the amounts involved were not large. More importantly, the growth of FDI has not been sustained in recent years, a period when many developing countries were attracting rising inflows.[9] FDI into Egypt rose during 1982 to 1986, with annual inflows growing from $294 to $1,217 million, and peaked in 1989 at $1,250 million. Thereafter, FDI fell to $253 million in 1990, recovering to $451 million by 1992. These flows are low relative to leading developing host countries (Table 4).

Second, the extent of industrial technology transfer was relatively low in the FDI that did come into Egypt. Much of the investment inflow went into non-industrial activities. Of industrial FDI, the bulk went into final stage assembly or packaging activities, with relatively low local technology and value-added content. Moreover, as the World Bank's 1994 report notes, "FDI was frequently encouraged as a 'package' including production technology, technical assistance, licensing agreements, use of trade marks and local content subcontracting preconditions. However, the involvement of Egyptian firms in enterprise set-up and operations has been limited to facilitating start-up procedures, securing access to local credit, and mediation with government; almost all of the R&D, training or transfer of know-how has been executed by the foreign partners in their headquarters or limited to the boundaries of their production facilities in Egypt, with little diffusion to the local market. Moreover, multinationals in Egypt have little incentive to use local research centres because of their weak capacity, while their investing in local own-labs has proved hard to justify in the absence of economies of scale." (Paragraph 2.30).

The relative inability of Egyptian industry to utilise fully the technology potential of FDI in turn reflects its weak technological capabilities. It also suggests that raising the level of inward FDI of the right 'quality' will require more than a liberal attitude to investors. It will call for a considerable strengthening of local capabilities, which attracts more complex activities. It will also call for a more coherent and targeted strategy of attracting suitable investors.[10] Current strategies of and institutions for FDI promotion in Egypt are fairly general, not based on a clear idea of which activities the country can offer a competitive or strategic base for foreign firms and so not targeted at maximising its assets. It does not match the aggressive and highly focused strategies pursued by the NIEs of East and South East Asia, which have excellent information and promotion systems and finely tuned incentive systems to guide investments into areas of export competitiveness.

F. 6. The Incentive Framework for Technological Activity

The main drive behind technology development is the incentive system in which firms operate, given by macro-economic and political conditions, competition in product markets, and the flexibility and responsiveness of factor markets. This provides the impetus for investments in improving competitiveness and the signals for resource allocation between activities and technologies. Egyptian industry has not been brought up in a system that is conducive to healthy technological development. The long legacy of centralised planning, public sector domination, high levels of import protection and inward-orientation, restraints on internal competition and other types of bureaucratic intervention, have all led to attitudes, habits and skills that are geared to "making do" within existing constraints rather than to cost efficiency and technological upgrading. These attitudes, habits and skills now constitute a serious barrier to upgrading, and they are not easy to change quickly.

There has, nevertheless, been significant improvement to the incentive regime in Egypt since the launch of liberalisation. Macro-economic management has improved. Many controls on domestic prices have been removed, while other prices have been brought closer to market-determined levels. The financial system has been liberalised. Trade has started to be freed up from non-tariff restrictions; tariffs are being lowered and their dispersion reduced. The dominant public sector is being gradually restructured and subjected to market discipline, and there is the beginnings of a privatisation process. Restrictions on entry and operation of private business are being removed and cumbersome licensing rules eased. Further regulatory and legal reforms are planned to furnish a proper climate for private business.

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[9] According to UNCTAD, *World Investment Report 1994*, total FDI flows to the developing world rose by 17% per annum over 1986-90, and by 25% in 1991, 32% in 1992 and a massive 54% in 1993. While much of the increase was concentrated in China, a number of other countries in Asia and Latin America also had significant increases in inflows in this period.

[10] See L. T. Wells and G. Wint, *Marketing a Country: Promotion as a Tool for Attracting Foreign Investment*, Washington, DC: International Finance Corporation, 1990.

While these improvements are creditable, they have deficiencies. On the macro-economic front, the real exchange rate has appreciated recently, and inflation and budget deficits continue at undesirable levels. There is considerable uncertainty on the direction, pace and irreversibility of reform. Tariff rates on final products remain fairly high (the maximum is 70%), and the projected pace and content of trade liberalisation are not clear. The liberalisation process seems to be haphazard and unrelated to any conscious strategy of upgrading industrial competitiveness. The rules of the game set by policy makers are not predictable; the policy process itself, lacking consultation with the private sector, is not transparent or understood. All this raises the risk and cost of private investment, and means that investments in long-term technology upgrading are adversely affected.

On the competition front, the regime still has a number of bureaucratic and regulatory barriers. As the World Bank puts it, "Most markets in Egypt are, in effect, noncontestable... the regulatory, legal and judicial systems .. impose huge costs on doing business in Egypt; being unrecoverable, these costs constitute a barrier to new market entrants who factor them in projected cash flows. In turn, such a barrier (or protection) reduces incentives for efficiency gains by the incumbent private sector".[11] For instance, labour laws, with complicated and costly procedures for dismissals, are a disincentive to entry and may distort technical choice and the direction of technological upgrading (biasing firms towards capital-using techniques and away from adaptations and improvements that use more labour). Anti-trust laws are antiquated by modern standards, not adequate to enforce a competitive regime. Multiple layers of directives and provisions, and a legacy of extensive regulations, weigh down the system of firm entry, exit and operations: there are still three types of approval required for investing in Egypt (many time-consuming and expensive). Local level regulations are extensive, cumbersome and demanding. Local content is promoted by offering import tariff credits, and can lead to inefficient in-house production of components to obtain cheaper imports. The complexity of the regulatory apparatus is exacerbated by overlapping jurisdictions between different departments, raising the costs of complying with regulations.

The Egyptian regulatory regime also inhibits the growth of micro and small enterprises by creating advantages to remaining small. Larger firms have to face more severe regulatory requirements in health, safety, environmental and employment conditions. This cost 'hump' in the growth of firms above a certain size can constitutes a barrier to technological upgrading (especially where large scales of operations are required). Finally, an important regulatory barrier to technological upgrading in Egypt is the restriction on the entry and operation of foreign-owned international trading companies. In most export-oriented economies in Asia, such companies have played an important role in bringing SMEs to the export market and diffusing information on design, quality, management and production technology.[12] The constriction of this source of technology upgrading may constitute a significant cost to the Egyptian economy.

G. 7. THE EGYPTIAN SCIENCE AND TECHNOLOGY SYSTEM

The industrial technology system in Egypt has three main streams, of which by far the most important is the *government* system. This falls under three ministries: Industry, Scientific Research, and the Public Enterprise Sector. Few of these government institutions (discussed at greater length below) have much direct connection with, or significant technological impact on, the private industrial sector. Their interaction is largely confined to conducting tests, providing mandatory standards certification and giving certain training, extension and information services to industry. However, the extent of this interaction is low, and much of the industrial sector operates effectively without linkages to the government technology infrastructure. SMEs are an important target for many of the institutions, but it seems that relatively few enterprises use them effectively. There is a general sense of isolation in the research institutes, while the institutions charged with providing operational assistance to SMEs are relatively passive or are under-equipped to fulfil their functions.

The other two, relatively minor, sources of technological assistance to industry are *specialised banks* and *universities*. The two banks that have technical departments offering assistance to the private sector are the Export Development Bank and the Industrial Development Bank. The former helps potential and actual exporters to enter world markets, and on occasion takes equity shares in ailing companies and helps them to

[11] World Bank (1994), Paragraph 2.28.

[12] This is shown for Korea by Y. W. Rhee, B. Ross-Larson and G. Pursell, *Korea's Competitive Edge: Managing the Entry into World Markets*, Johns Hopkins Press, 1984.

restructure financially and technologically (it currently has shares in 10 companies, of which 6 are in manufacturing). The support to enter export markets, albeit indirectly, opens up a source of technical information for its clients. The Export Bank also has a number of engineers in its project finance department who can evaluate technical issues and offer advice. The Industrial Development Bank offers more direct help with technology. It employs 13 engineers and 4 technical diploma holders in the head office, and a few more in its 8 regional branch offices. Its engineering department helps clients with feasibility studies of each project, including a detailed analysis of feasible technological options. Its Customer Services section has contact with the Industrial Design Development Centre and can help clients with product design. The Bank also helps to rehabilitate firms that have run into financial difficulties. In some cases, it takes an equity position to help the restructuring, which may involve technological upgrading.

The engineering departments of universities have some linkages to industrial enterprises. A good example is the Development Research and Technological Planning Centre (DRTPC) in Cairo University. This Centre provides a set of valuable technological and training services to industry, mainly in the energy and anti-pollution areas, on a full cost basis. By shifting its focus to the private sector and marketing itself better, the Centre has been able to dramatically increase its earnings. Information on industry linkages with other universities is not available; impressionistic evidence suggests, however, that they are not strong.

In general, the technology system in Egypt is not geared to meeting the needs of industrial restructuring and technology upgrading. There are few institutions capable of delivering the information, services, training and research that may be needed by industry, especially by SMEs, to modernise existing production capabilities and keep up with changing technologies. However, the system as such has most of the institutions in place that would be needed. The next section reviews the main institutions involved.

H. 8. Technology Support Institutions

Access to foreign technology (apart from FDI) is a vital ingredient of technological upgrading. This access involves the ability to import capital goods and technical information and services (licences, know-how, turnkey projects, and the services of consulting firms and individual experts) at a reasonable cost and without bureaucratic delays or interventions. The current framework in Egypt is favourable. It places few restrictions on imported equipment or the licensing of foreign technologies. Tariff rates on imported equipment are not high and are to be further reduced: average tariffs on equipment fell from 17.1% in 1993 to 13.5% in mid-1994 and are expected to reach 8% by end-1995. As far as licensing is concerned, there is no official interference in the choice of foreign technologies or in the terms negotiated.

However, access to technology *per se* is not enough to ensure its proper purchase and absorption: buyers have to know where and how to purchase the technology, and then have to invest in mastering the technology and adapting it to local conditions. There are deficiencies on this front. Large Egyptian enterprises tend to be well informed on international sources and prices of technology, and depend heavily on foreign collaboration for all their technological needs. They do not, however, always negotiate properly on the conditions and 'depth' of technology transfer.[13] In contrast to their counterparts in countries like Korea and Taiwan, they tend not to build upon the technology import to develop their own capabilities. This is reflected in low expenditures on local R&D, and in their propensity to keep licensing passively new vintages of technology. There is little confidence in technologies generated locally, by government research institutes or even by in-house laboratories of enterprises, whose managers prefer tested and proven foreign technologies.

Small and medium enterprises in Egypt, to the limited extent that they are interested in foreign technologies, lack contact with international markets and so are poorly prepared to locate and obtain good prices for foreign technologies. As compared to large firms, they are even less able to absorb and, over time, improve upon, these technologies. This is not unusual: in developing countries SMEs generally face high transactions costs in buying foreign technologies, and lack the resources to build their independent capabilities. Negotiating the fragmented and imperfect international technology market requires large minimum investments in collecting

[13] The same technology can be transferred with little design, training and upgrading, resulting in a "shallow" transfer which does not allow the transferee to keep up with changes or to build upon the information provided, or with a great deal of design methodology, commitment to upgrade and training of high level local personnel, resulting in a "deep" transfer. Korean firms are reputed to bargain strongly to obtain "deep" transfers in order to develop their own technological capabilities.

information and undertaking complex bargaining. Most countries have mechanisms to help SMEs in accessing technologies; among the more successful ones are countries like Korea and Japan that have developed institutional means to help their smaller enterprises. These provide information on alternative sources, prices and terms of foreign technologies, and back this up with other measures to help small enterprises to upgrade and develop their own technological capabilities.[14]

The Egyptian government does not offer comparable assistance to local firms. The General Organization for Industrialization (GOFI) in the Ministry of Industry contains a unit, the Industrial and Technology Information Bank (INTIB), to collect and provide information on sources of technology. INTIB is supposed to advise local firms, in particular SMEs, on alternative sources of foreign technology and help them to negotiate good terms and conditions. It is staffed by 10 engineers and technicians and has access to international data bases on technology. However, most small firms are unaware of the existence of INTIB or, if they are, that they do not use its services extensively. Large firms practically make no use of its services. INTIB lacks hands-on experience of technology transfer. Moreover, the Ministry does not provide a package of finance, technical extension or adaptation together with information that would make technology imports feasible for a large number of firms. INTIB has therefore had no significant impact on industrial technology imports.

Technology Diffusion; Extension services for SMEs are provided mainly by the Industrial Design and Development Centre (IDDC). The IDDC was formed by merging the Electronics Industry R&D Centre, the Small Scale Technical Extension Service and the Machinery Design and Development Centre. It was originally under the Ministry of Industry, but was 'corporatized' (turned into a company, but not in private hands) in 1988. It stayed under MOI until July 1992, when it was placed under the Engineering Holding Company under the new Ministry of Public Enterprise Sector. This move gave it more autonomy in its operations and the freedom to offer more incentives to its staff. At the same time, however, its financing was changed from a grant from the Ministry of Finance covering all its expenses to more restricted allocations for its holding company, which now contributes only around 40% of the Centre's expenditures. The proportion earned by the Centre rose from around 10% to the present 60%, and the objective is for the Centre to become financially fully self-supporting. However, in the process the Centre has not been able to greatly improve its technical services.

The IDDC has three divisions (Electronics R&D, Machinery Design and Development, and Management Consultancy) as well as the SSI Extension Service, reflecting the origins of the institutions that were merged to create it. It employs a total of 520 people, of which 250 are administrative staff, a top-heavy structure that impairs efficiency but is difficult to change under existing labour regulations which make it very difficult to fire staff. The Electronics Department has 40 engineers and technicians. It suffers from a high turnover (around 15-20% per annum) of its younger and better engineers, but is unable to compete with the business sector that seeks trained personnel. Its function is to develop designs and prototypes for manufacture by industry, and to diffuse new technologies to SMEs. However, the main activity of the department is now to manufacture simple spares for electronics and to repair and maintain microelectronics-based controls. The department has a separate training centre to offer courses to employees of public and private companies. The numbers trained have dropped from 250 a year until 1992 to around 150 a year since, caused by a drop in public enterprise training. Efforts are being made to attract private sector trainees, but there is little interest from the large companies. SMEs are more responsive, but the numbers involved are very small.

The Machinery Design and Development Centre has some design engineers and a workshop to develop prototypes for tools, jigs, fixtures and moulds for industry. As with the electronics department, however, it tries to earn revenues by manufacturing and selling tools and fixtures in the market, and does not break even. Its design engineers have been trained by two visiting German engineers and two have been sent to Japan for training. And, as in electronics, its young engineers have high turnover rates. The workshop has only skilled workers but no engineers, and the technical quality of its work needs to be improved. The Management

[14] SMEs even in developed countries like the USA face handicaps in buying foreign technologies and equipment relative to Japan, because the kind of network of institutional and government support given in the latter tends to be far stronger and more varied, including financial support, information, technology demonstration centres, leasing systems, training facilities and so on. Simply in terms of loans and loan guarantees to SMEs, "the Japanese government provides about 20 times more financial aid to small business than the US government does." Office of Technology Assessment, US Congress, *Making Things Better: Competing in Manufacturing*, Washington, DC, 1990, p. 162.

Consultancy unit, with 11 staff, offers financial and other types of advice to SMEs, using engineers with financial training. However, the financial expertise of the unit is weak.

The SSI Extension Unit has 22 employees, and can draw upon other departments in the IDDC as necessary. It operates 11 mobile units which visit enterprises on their own initiative, some of which are served free (mostly financed by a US AID project) and others are charged a subsidised rate. The extension service offers two types of help: on general management and on specific technical problems. During the first diagnostic visit, the Unit discusses problems in general terms without charge, though some minor technical problems can also be solved during the diagnostic visit. If there is serious interest in the enterprise, it follows it up by more specialised management or technical staff; this is charged for at a subsidised rate. The most active area is maintenance management, and there is a large backlog of work on this. Production management is also in demand, but the Centre is short of qualified engineers in this speciality. In 1994, the Unit made 460 visits, of which 356 were first time and 104 follow-ups.

An institution like the IDDC is placed to serve a vital technological function in upgrading SMEs in Egypt. These enterprise are, as noted earlier, generally backward in their operating technology and quality. Most have no production control or quality assurance systems. Their management practices are inadequate, and their knowledge of new technologies and equipment is very patchy. They invest little or nothing in training their workers or in collecting relevant technical or market information. However, most enterprises are unaware of their deficiencies and are unwilling to pay for advice, assistance and training even at the subsidised rates offered. Most entrepreneurs blame their poor performance on the shortage of credit or on market conditions rather than on their own shortcomings; this is especially true of older entrepreneurs with a traditional craft technological background.[15] While entrepreneurs with modern education are more aware of their technological problems and are more receptive to extension services, even they tend to consider the adoption of new technologies risky because of their inability to meet the training needs of new technologies. In Hong Kong and Taiwan, governments have created Productivity Centres to adapt technologies to local needs and to demonstrate their feasibility to enterprises, train employees and offer subsidised consultancy services supported by financial assistance.

However, there appear to be severe deficiencies in IDDC's present capabilities to offer such assistance to SMEs. Its facilities are badly run down; private sector demand for its services seems to be declining; its workshop equipment is old (and half of its extension vehicles are barely serviceable); a lot of redundant staff are kept in employment; and its president and his deputy are both trying to leave the institution. This general demoralisation and disrepair are due to a mixture of lack of resources, poor management and an inability to attract private sector custom. Egypt clearly needs a Productivity Centre along the lines of East Asian NIEs, with adequate staffing, equipment and financial resources. The experience of the NIEs also suggests that it is necessary for Egyptian support institutions to adopt a more pro-active in providing extension, visiting more SMEs, making them realise the nature and extent of their technological deficiencies, and offering practical solutions accompanied by means of financing the upgrading (as opposed to the present approach of waiting for enterprises to come and ask for assistance).

Standards and metrology institutes: There are two institutions in Egypt dealing with standards and quality. The National Institute of Standards (NIS), the body in charge of metrology and calibration, comes under the Ministry of Scientific Research. The Egyptian Organisation for Standardisation (EOS), the institution responsible for keeping and enforcing mandatory standards, comes under the Ministry of Industry. In addition, there is a weights and measures service of the Ministry of Supply and Trade. The NIS is fully funded by the government, and employs about 300 persons, of whom 126 are engineering graduates (including 64 doctorates and 25 MScs) and another 16 are technical diploma holders. It is making a serious attempt to propagate the ISO 9000 series to Egyptian industry, and has recently established a Total Quality Consultancy Unit, staffed by four doctorates, to provide assistance to firms. It is collaborating with German standards institution in its ISO 9000 drive, and is negotiating to send personnel to the British Standards Institute for training in accreditation if it can raise the money needed. The funding provided is inadequate for the NIS to discharge its functions, and significant parts of it measuring equipment is now obsolete.

[15] This is a common problem in developing countries, as shown in a recent study of technological capabilities in Ghana financed by the World Bank. See S. Lall, G. B. Navaretti, S. Teitel and G. Wignaraja, *Technology and Enterprise Development*, London: Macmillan, 1994.

The EOS (now called the General Organization for Standardisation and Quality Control) is the depository of ISO and other foreign, regional and local standards, and provides the main testing, inspection and quality control services to Egyptian industry. It operates some 100 National Technical Committees, each comprising representatives of the government, universities and industry, which elaborate and revise standards for different activities. There are around 3000 Egyptian standards, of which around 300 are mandatory; the use of recognised foreign standards is allowed where relevant local standards do not exist. The EOS employs around 700 people, of which 60 are standards engineers; there are also 130 engineers and scientists and 40 technicians in 5 laboratories. It maintains a library of necessary documentation on standards, and is prepared to provide consultation on how to apply for ISO 9000 standards (the actual consultancy for upgrading quality systems is provided by private, largely foreign affiliated, consultants). The EOS is presently playing a relatively passive role in propagating quality upgrading in Egyptian industry.

The present cost of obtaining ISO 9000 certification in Egypt is estimated at US$30-60 thousand for preparation, and another US$35 thousand for certification (by a foreign company). This applies for large enterprises with good production systems in place and well-trained personnel; it is higher for firms that are further behind quality frontiers. Only nine firms in Egypt have obtained ISO 9000 certification till now, all foreign affiliates or joint ventures, though several large local companies have expressed an interest in obtaining certification. SMEs seem largely unaware of the desirability of such certification in the future, and in any case would find the cost a major deterrent — unless financial assistance were offered and they saw rapid payoffs in terms of domestic sales and export growth. The cost of certification could be lowered by developing local consultancy and certification capabilities, and by encouraging the growth of private consultancy and accreditation services.

Local Subcontracting: One of the most important mechanisms for the diffusion of technology is the creation of strong supply linkages between large and small enterprises, and between local firms and foreign buyers. Such linkages are weak in Egypt. A recent study of subcontracting between foreign affiliates and local firms found that supply linkages, while they existed, were weak by international standards even in 'linkage-intensive' industries like automobiles or consumer durables.[16] This was traced to several factors: the legacy of planning and dominance of public enterprises; the protected inward-oriented industrialization which give little incentive for cost-reduction and specialisation while encouraging vertical integration to counter difficulties in sourcing foreign inputs; poor communication and lack of information between large (particularly foreign) and small enterprises; regulations affecting the growth of SMEs; and, for present purposes the most important, the lack of technological capabilities among potential suppliers leading to poor quality, high cost and unreliable deliveries.

The encouragement of domestic linkages is always a difficult task, since SMEs in all developing countries tend to suffer technological gaps and have to be "brought up" by large principals, which have to invest resources and skills in providing technical know-how, training, troubleshooting, designs and so on. This process of bringing up suppliers can however be greatly facilitated if institutions exist to provide training, technical extension and financial support to SMEs. Egypt has, like many developing countries, sought to encourage local suppliers by imposing local content requirements on new activities. While this has forced firms to invest in developing some local suppliers (or in increasing their vertical integration), it has also led to the promotion of inefficient suppliers. Egypt has now relaxed mandatory local content requirements but continues to give strong incentives for increasing local content linked to tariff provisions. As noted above, this too may have undesirable consequences.

The Egyptian government is making some efforts to promote the capabilities of local suppliers. Apart from the extension and other programmes noted above, GOFI has launched a "Feeding and Loading Industry Programme" that seeks to develop the technical, managerial and marketing skills of local suppliers and to establish a database on potential suppliers and subcontractors. The programme is to start with the engineering industry and then to extend to textiles and eventually all other industries. It is presently too early to judge the effectiveness of this initiative.

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[16] International Finance Corporation and Foreign Investment Advisory Service, *Linkages Between Egyptian and Foreign Firms*, Draft. Washington, DC, 1993.

Linkages between foreign buyers and local firms are common in the garment industry; these linkages help local firms to upgrade quality, production processes, equipment and layout.[17] However, the low volume of garment exports by Egypt means that buyer-seller linkages have been small and have not fed into the technological development of the industries concerned. One reason for this low volume of garment sourcing in Egypt may be that foreign buyers find it difficult and costly to locate and contract local suppliers (wage levels in Egypt are competitive with many Asian countries and the level of skills is comparable or better). High 'transaction costs' in striking seller-buyer relations may in turn be due to bureaucratic impediments, information gaps on the capabilities of local suppliers, lack of marketing Egyptian potential in the relevant centres (in Asia, for instance, much of garment sourcing is handled from Hong Kong) or infrastructure deficiencies. All these can be overcome by appropriate policy reforms and initiatives. As in Hong Kong, the government could establish a high-powered information and 'match-making' service to help buyers and sellers contact each other, and to vouch for the quality of registered suppliers. Egypt lacks a similar organisation.

I. 9. PUBLIC R&D INSTITUTES AND INDUSTRIAL R&D

Public R&D Institutes: The Ministry of Scientific Research oversees nine specialised research centres (including the National Institute of Standards, described earlier). Of these, three are directly concerned with industry: the National Research Centre (NRC), the Central Metallurgical Research and Development Institute (CMRDI) and the Electronics Research Institute. Of these, we are able to describe the first two.

The NRC is the first and largest government research centre in Egypt, and also the largest research centre in the Middle East outside of Israel. It started in 1956, and has since spawned off many of the other research centres in the country. It employs around 6,000 people, about half of whom are scientists, engineers and technicians engaged in research, and the remainder are in management and administration. Of the researchers, there are 1,120 doctorates (450 at the professorial level, 270 at the assistant professor level and 400 at the lecturer level). It is divided into 13 divisions, further subdivided into 59 departments; each division is like a faculty in a university, and pays at the same grades as the university. It has three sources of finance: the government budget, which pays for the bulk of its expenditures (all the salaries, overheads and about 50% of research work); private and public enterprise and institutional contracts (for about 30% of research); and international grants and projects (for the remaining 20% of research). The money earned on research contracts and projects is used to pay bonuses to the researcher teams involved (but not to individual researchers) and to purchase equipment and research materials. In all, 90-95 per cent of its expenditure is financed by government grants.

The NRC's Board is made up of its division heads and representatives of the Ministries of Industry and Agriculture, the head of the Academy of Science, and an eminent lawyer. There is no representative of the private industrial sector. Its hiring and firing are subject to the same restrictions that govern all official employment, and it carries a significant amount of 'deadwood' both in research and in administration. The management of R&D and its marketing to industry are weak, and relatively little work is done for private firms; its culture is geared to academic rather than applied research. As a result, private industry has little information about, or interest in, the capabilities of the NRC. Its equipment is outdated and inadequate; the organisation even lacks a computer network. Government financial support is expanding slowly, but not sufficiently to bring the research facilities up to modern standards.

The management of the NRC is well aware of its deficiencies and is trying to promote more industry-oriented research. As a result, some collaborations between its researchers and private firms has emerged in recent years.[18] However, a sweeping change in the NRC's institutional 'culture' is hampered by its structure and

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[17] See D. B. Keesing and S. Lall, "Marketing Manufactured Exports from Developing Countries: Learning Sequences and Public Support", in G. K. Helleiner (ed.), *Trade Policy, Industrialization and Development: New Perspectives*, Oxford: Clarendon Press, 1992.

[18] A good example is Gaspo, the only local firm making natural flavours and colours for food processing. GASPO developed its products in collaboration with a scientist from the NRC's Centre for Radiation Research, and is now able to export about half of its output. The Centre also provided testing and sterilisation services, and helped to upgrade the quality of the flavours and colours as well as to develop entirely new products. The collaboration was encouraged by the research institute, which allows its researchers to work for industry for a specific number of hours each week.

legacy: rigid employment practices, the inherited attitudes and values of researchers, the burden of 'deadwood', the inability to give individual incentives for good performance, the support provided by the government budget and its marketing deficiencies. Private sector representation on the Board would help to reorient the institution if these problems could be addressed. However, the main need seems to be to give a strong impetus to the Centre to earn a much greater proportion of its total budget from the sale of services. Such major reform does not seem to be on the agenda.

The Central Metallurgical Research and Development Institute (CMDRI) was formerly part of the NRC, but became independent in 1982. Its staff of 300 (of whom around half are scientists, engineers and technicians) conducts research into applied problems of the metalworking industry and offers training in casting, welding, foundry and related technologies. It has 40 sections with different specialisations and laboratories, of which 15 have some direct involvement with industry; its pilot foundry makes and sells special castings to industry. CMRDI's links with industry have been slow to develop, and the government continues to provide most of its revenues. However, it claims to be most advanced in establishing links with industry of all the government research institutes in Egypt. Most of its contracts have been with public enterprises, though the proportion of private contracts is increasing.

In the private sector, CMDRI's main clients are small and medium-sized engineering firms. However, these firms come to it mainly for immediate production-related problems, such as testing, analysis and technical consultancy, rather than with research contracts, for which they see little need. This reinforces the impression about the relatively low level of technological capabilities in the small scale sector of Egyptian industry, and the correspondingly low awareness of the need for upgrading and innovation. An important function of the technology support institutions must be to change this awareness by more aggressive policies and programmes.[19] However, the deficiency does not lie only with industrial firms — the official institutions are also not geared to providing the specific services that industry requires. Many CMRDI researchers lack practical process know-how and experience of industrial operations, and the best researchers are reluctant to work on practical problems.

The experience of these two institutions suggests that the basic structure of Egyptian public R&D institutions needs to be reformed to make them relevant to industry's technological needs. That this kind of reform is feasible is shown by the experience of other countries. For instance, India has a similar system of public research institutes that traditionally contributed little to industrial technology. However, with some liberalisation of the Indian economy, growing competition in the internal market, and cuts in the institutes' budget support, this has changed. Many institutes are making aggressive efforts to sell their services to industry and many firms are finding it useful to use their services and place research contracts with them.

Industrial R&D: The encouragement of industry to use public research institutes has to be accompanied by active in-house R&D by industry, since the main impetus for, and inputs into, industrial research come from industrial enterprises themselves.[20] Moreover, the industrial sector can draw upon public research institutions best when it has the capability to evaluate and formulate its own technological needs. As noted, however, the Egyptian private sector conducts very little formal R&D. In large part this is due to past policies and the 'culture' of dependence on imported technologies. However, it is also partly due to the neglect of government support for industrial R&D. For instance, R&D expenditures by firms are tax deductible in theory, but such deductions are not given in practice because tax officials tend not to concede this as a legitimate business expense.

Many NIEs in East Asia offer much stronger incentives for industrial R&D than Egypt. They give more than full deduction for R&D expenses (e.g. 200 per cent in Malaysia and 125 per cent in Korea), in addition to accelerated depreciation, duty free access to research equipment and materials, and relatively easy access to foreign consultants. This is generally supported by strong publicity campaigns and pressures on firms to increase their local design and development activity. Special incentives are often given to foreign investors

[19] A relevant initiative launched by the CMRDI is to set up "technology incubators" in six new industrial cities to produce parts and components for industry. The institution plans to identify potential local entrepreneurs in each location and teach them the technology, help launch production, conduct testing and offer continuing technical assistance. The project is now at the stage of acquiring land and buildings and surveying the specific needs of the industrial cities.

[20] On the evolution of private R&D and supporting institutions in the developed countries see D. C. Mowery and N. Rosenberg, *Technology and the Pursuit of Economic Growth*, Cambridge: Cambridge University Press, 1989.

that agree to increase local R&D activity. SMEs are given financial support for undertaking technology upgrading. Special funds and grants are generally provided for contracting research to government institutes. In addition, most NIEs (including Korea, Taiwan and Singapore) have technology targets by activity and product to guide research activity. The most technologically most advanced NIE, Korea, gives grants and subsidised credit for R&D into areas of 'national interest'. Even the normally *laissez faire* Hong Kong government has recently launched initiatives to support industrial R&D to help keep up with technological development in high-technology activities in its more interventionist neighbours. There are clear lessons for Egypt in these experiences.

J. 10. Finance of Technological Activity

The financing of private industry in Egypt is limited to the banking system, which offers only a limited range of financing instruments and terms. The longest term for bank lending for the private sector is five years, with the average loan's maturity being two and a half years. Micro and small enterprises receive virtually no formal credit. This lack of long- term credit imposes an acute constraint to the development of the private sector, and may affect investments in technology upgrading more than other aspects of financial operations. Investments in acquiring new equipment, retraining, technological effort and formal R&D yield returns in the longer term, and normal commercial banks find it difficult to assess their benefits. The conservative nature of Egyptian banking, and its bias towards short-term lending to well-established large companies, is clearly not suited to financing technological activity. At the same time, the equity market is underdeveloped, and there are no specialised intermediaries that could assess technological investments before it could finance technology upgrading. SMEs are in a much more difficult position in raising finance for technological activity.

Most industrialising countries in the developing world have set up specialised intermediaries and venture capital funds to promote technological activity. Korea is the most successful, and there are now some 58 VC firms managing about $750 million of funds. Other developing countries in Asia like India, Singapore, Taiwan and Hong Kong also have growing VC activities, as do the larger Latin America countries. Venture capital funds are especially valuable in promoting the growth of new enterprises by technocrats or by entrants with management or engineering backgrounds. This is best done where the VC fund has the capability to give hands-on support to borrowers or equity partners, and is staffed and managed by personnel with experience of technology and business operation. The instruments have been flexible, tailored to suit individual client needs and preferences. Again, these experiences offer lessons for Egypt.

K. 11. Conclusions

Egypt clearly has a long way to go before its technology system is able to meet the needs of an outward-looking and competitive industrial sector. Some of the deficiencies affecting industrial technology development lie outside the scope of 'technology policy' in the narrow sense. Others are directly related to the science and technology system.

As far as the broader considerations of policy go, the 'incentive' regime needs further reform and market orientation, and the liberalization programme should be persisted in. However, any further liberalisation should be phased carefully rather than be imposed rapidly and indiscriminately. The process should take into account the differing needs of technological upgrading in different industries, exposing those that are near world levels of competitiveness to import competition fairly quickly while allowing those with greater "relearning" needs more time to restructure and adjust. The Asian experience shows that the best way to subject industry to international competition is to have a clear and firm programme of opening up to foreign competition, with some scope for the strategic direction of industrial activity.

Slowing down the liberalisation process is not, by itself, the answer to problems of technological backwardness. It has to be supported by, and integrated with, measures to persuade firms to invest in upgrading their capabilities and supply-side measures to meet gaps in factor markets. Many Egyptian firms are not aware of their technological status and needs — these needs have to be forcefully communicated to them, especially to the SMEs that are more removed from world technology trends. On the supply side, measures have to be mounted on a variety of fronts: to improve standards and quality assurance, public research institutes, technology extension and support services for SMEs, training, R&D and technology upgrading in the large-scale private enterprises, and finance for technology development. The pace of import liberalisation has to be linked to the pace of upgrading of these services, since it would be wasteful to expose industry to international competition without providing them the support they need to meet this competition. There is, in sum, a need for a coherent *strategy* to enhance industrial competitiveness. As in many developing countries, the government is opening up in a haphazard and *ad hoc* manner, neglecting the market failures that affect the process of technology development. If the need for policy support in this process is recognised and addressed, countries can greatly accelerate their growth and industrialisation. If it is ignored, the process can be retarded and distorted.

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