Industrial Policy in Historical Perspective[1]

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1 Historical Perspective

The question of whether governments should pursue a policy of selectively encouraging specific manufacturing sectors relative to others has been a staple of economic analysis and policy for 50 years. It goes back a century and a half if analyses of early efforts at protection of infant industries in Western Europe are included. There is agreement that governments need to provide those goods subject to large scale economies and those which generate significant externalities. Ports and electricity generation are examples of the former, education of the latter. The role of the government is not limited to classic public goods from which users cannot be excluded – charges can be made for both electricity and ports but these have generally been viewed as beyond the scope of private financing at early stages of development though this may be changing. Education is usually viewed as a joint good – providing the fundamentals of good citizenship plus economic skills valuable to potential employers.[2] There are many market failures that governments can potentially address in a quest to jump start industrial development.[3] In the 1980s there were a spate of studies arguing that the Korean and Taiwanese governments had done precisely this in the 1960s and 1970s. More recent analyses utilizing longer term data are more skeptical of this success.[4]

Efforts in Korea and Taiwan, following a template devised by Japanese policy makers in the early postwar years, are only a small subset of national policies designed to catalyze industrial development. Tariffs, quantitative restrictions, subsidized interest and public utility that differ among sectors were also used very intensively by scores of nations, initially in Latin America and India, then throughout the developing world.

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[2] A good survey of the role of governments in the early history of OECD countries is provided by Lin and Monga, 2010.

[3] Pack and Saggi (2006) provides an extensive discussion of the market failures that potentially could be addressed by industrial policy. Pack and Westphal (1986) attempted to demonstrate that the Korean government had addressed many of these successfully in its early efforts to industrialize.

[4] On Korea see Jones and Sakong, 1980, and Pack and Westphal, 1986. On Taiwan see Wade, 1990. For a review and synthesis of more recent studies see Noland and Pack, 2003.

However, programs of import substituting industrialization (ISI) throughout much of the developing world are viewed largely as a failure, a conclusion often ignored in the enthusiasm inspired by the alleged success of industrial policy in a few Asian nations. Three examples of high achievement versus scores of failures imply that that the odds of success are not high though policy makers, like over-optimistic investors in the dot com and housing bubbles, might argue that "this time it's different." The question is not whether a few projects or sectors fail – that is to be expected - but this issue is whether, in the aggregate, industrial policy has been successful.

Skepticism about the beneficial effects of "hard" industrial policies (picking individual sectors or winners) has metamorphosed into an urging of "soft" policies that have predecessors in French planning of the post-WWII period and Japanese "deliberation" councils. These councils attempt to put together the government and relevant private sector actors to inform each other of perceived bottlenecks and may facilitate investment coordination among private sectors and between governments and private firms. The design and likely impact of both hard and soft policies has received increasing attention given the failure of many of the poorest countries to diversify their economies and their difficulties in providing productive employment for a rapidly growing labor force. Occasionally there is a blurring of the lines about industrial policy – any activity that helps one industry is lumped under the rubric of an industrial policy even if it involves only mproved food inspection that facilitates exports. Such elastic definitions may obscure the issues which are now arising in the main region of interest, sub-Saharan Africa in which there has been little diversification from primary products to manufacturing and where there is considerable effort to think through policies that might foster such diversification. Largely under the radar screen, many of the non-oil Arab economies have the same pattern and in these nations with labor force growth even greater than that of the African nations, the small size and slow growth of the manufacturing sector presents policy dilemmas not very different from those facing African countries (Noland and Pack, 2007).

Much of the optimism about the potential of "hard" policies to accelerate economic growth is derived from the experience of a few Asian countries, Korea and Taiwan (KT) whose experience for a historically brief period, roughly 1965-90, suggests that industrial policies may have played a role in their growth acceleration. Japan is often investigated as well but its experience after WWII is not a particularly apt example of industrial policy as the role of Japanese policy makers was to restore the economic prowess that had existed before World War II. Japan displayed advanced industrial capabilities not only in World War II but had deployed battleships in defeating Russia in the Russo-Japanese war of 1905. There are, however, many empirical studies that question the validity of a major role of industrial policy in these nations.[5] But even if it were correct, it is necessary to consider the total constellation of development policies which included provision of social overhead, relatively conservative macro policies, and encouragement of the utilization of foreign technology. Korea and Taiwan constitute only two observations in a very large set of selective efforts at industrialization.

Almost every developing nation has engaged in such efforts, most using the same arsenal of policies including protecting the domestic market and subsidies of various forms. Four decades ago, three landmark sets of studies were undertaken under the auspices of the OECD, the National Bureau of Economic Research, and the World Bank.[6] Countries ranging from Argentina to India were analyzed in numerous articles and monographs. These described the efforts at import substituting industrialization and evaluated their success through the mid-60s to mid-70s. Many other nations not included in these studies pursued the same set of policies but their experience was not accorded the same scrutiny.

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[5] Noland and Pack (2003) contains a detailed review of the evidence on Japan, Korea, and Taiwan. See also Harrison and Rodriquez-Clare, 2009.

[6] Little, Scitovsky, and Scott, 1979, Balassa and Associates, 1982, Bhagwati, 1979, Krueger, 1978 are summary volumes. Monographs and articles on individual countries providing the basis for the summaries are cited in these volumes.

Almost four decades after these studies it is appropriate to ask how the countries fared in the next decades. Were industrial policies outside of the Asian nations successful in promoting general economic growth or industrial development? One objection made by some critics of the earlier studies was that they were premature, i.e., the transition from infant industry to adolescence was prolonged and the path to adulthood was even more protracted. But evaluation is a very difficult issue because of the often vague goals of ISI programs. The goals could be interpreted in many ways – to improve per capita income by facilitating a transformation of the economy from low (agriculture) to high (manufacturing) productivity sectors, to increase the relative importance of advanced sectors within manufacturing, to become self sufficient in manufactured products, to facilitate "modernization" and so on. Normatively the only sensible criterion was to increase per capita income and in narrow terms the success in individual sectors should be evaluated within a benefit-cost framework using the Mill-Bastable criterion (Corden 1974).

Section 2 examines the relative size of the manufacturing sector in some of the major LDCs that pursued import substituting industrialization (ISI) and those that pursued more externally oriented policies. The success in increasing the relative size of manufacturing is one criterion used as this was the goal of many advocates and this goal is being increasingly articulated as relevant for the African economies (Lin and Monga, forthcoming, Page, 2009). The growth of the entire economy is also considered as the major effort to industrialize had economy wide effects insofar as promoting some sectors required *de facto* discrimination against others in higher prices for inputs or taxation to pay the budgetary cost ofr subsidies. In addition, I consider measures of technological upgrading to allow for the pursuit of goals other than simple growth in the aggregate importance of manufacturing. Section 3 asks whether the role of industrial policy in the success of some countries can convincingly be attributed to industrial policy given the many other simultaneous policies that were followed to stimulate investment, education, infrastructure investment and efforts to facilitate international technology transfer. Section 4 presents a brief summary of the spectacular growth of the Indian software sector which was largely the result of private efforts and can be viewed as an island of free enterprise in an ocean of government dominated policy at the time of its major acceleration. Section 5 notes the atypical historical legacy of Korea and Taiwan and Section 6 considers the implications of this historical perspective for the probable impact of efforts to foster African industrial growth. I proceed in increments to look at the evidence of the success of efforts to stimulate manufacturing growth in nations that underwent intensive ISI. No one piece of evidence is definitive but I hope that the accretion of some key differences among the Asian and ISI countries establishes a convincing case that there were so many components of Korean and Taiwanese growth, that singling out "hard" industrial policies as decisive is very questionable.

2. The Evidence on Manufacturing's Role

2a. The size of manufacturing

Figure 1 shows the share in each country of manufacturing value added in total value added, (VA_M/VA), from 1960 to 2009 The simple picture is quite clear: the Latin American nations all undergo a substantial decrease in (VA_M/VA) from their peaks. In some countries such as Argentina and Brazil this decline is enormous, from well over 30 percent to around 15 percent in the case of Brazil. Even Mexico, despite NAFTA, does not have a sustained increased in (VA_M/VA). It is likely that the ratios in the early years were an artifact of high effective rates of protection (ERP) which afforded higher tariff rates to final goods than to intermediates, thus artificially inflating the value added in manufacturing relative to other sectors such as agriculture.[7] Even with a half century of intensive ISI the Latin American countries have reverted to their historic mid-century role of commodity exporters, to the chagrin of the ghosts of Prebisch and Singer. The non-Latin American nations of Kenya, Cote d'ivore and Egypt and India never really had a growth in manufacturing's importance. Only Korea and a few of the other Asian

[7] ERP = (Value added at domestic prices – value added at world prices)/value added at world prices or (VA_D-VA_W)/VA_W. The numerator reflects the net impact of tariffs and quantitative restrictions on both final product and purchased traded goods prices. For estimates see the studies cited in footnote 4.

nations maintain their ratios. Indonesia and Thailand avoided the relative decline of manufacturing despite rapid growth, suggesting that intensive industrial policies were not a pre-requisite to sustained industrialization. The precipitous drop in Hong Kong and Singapore reflect a move to service sectors that reflect an evolving comparative advantage.

The observed pattern in ISI economies cannot be explained by the normal decline in VA_M/VA on the basis of Engel curves as the Asian countries experienced much more rapid growth in per capita incomes. The most likely explanation of the decline in VA_M/VA is the lack of competitiveness of the production that was undertaken under ISI, an interpretation buttressed by the decline in the Latin American-Caribbean (LAC) share of contested international markets shown in Figure 2. LAC's share of manufacturing exports has declined and its absolute exports are now below those of the ECA, the former soviet bloc nations despite the much later emergence of this group into international markets after decades of bilateral trade with the Soviet Union.

These patterns show that industrial policies, interpreted here to be those promoting manufacturing in general or selective sectors have not succeeded in terms of a sustained structural transformation (VA_M/VA) nor in competitiveness. Even if some individual firms or sectors can be cited that have done well[8], these successes have not, in the aggregate, been sufficient to offset the weak performance of either inefficient promoted sectors or those that were neglected and implicitly discriminated against. The earlier studies that measured the impact of ISI policies typically found annual costs of intersectoral misallocation of resources of 2-3 percent of GNP and a considerably greater percentage of manufacturing value added. Both capital and labor were allocated to sectors in which the countries had no static or long term comparative advantage. Largely arbitrary levels of effective rates of protection among sectors characterized all countries and protection was maintained without implementing any system of incentives

[8] Interesting but idiosyncratic examples of success are provided in Chandra, 2006. With enough encouragement, a few firms can undoubtedly achieve substantial growth - the key issue is whether such success is likely to be widespread.

that would encourage firms to improve productivity to survive.[9] In contrast, Korea and Taiwan (and Japan before them) all provided considerable protection in the domestic market to their industries but combined this with rules that forced firms to learn or wither. Other nations did not employ a stick as well as a carrot. In ISI countries firms were able to earn sufficient profits in the domestic market to allow them to do well enough without exerting more effort to become more efficient though this might have yielded still greater profits.[10]

What should one expect if IP had been successful? A strict test would utilize the Mill-Bastable criterion – the PDV of additional producer surplus be greater than the PDV of foregone consumer surplus. This requires structural estimates of the demand and supply curves for each year for each sector - clearly beyond the available data. Effective rates of protection basically measure excess production costs incurred due to the protection regime but do not measure any loss in consumer surplus. The static allocative losses were almost certainly dwarfed by the reduction of total factor productivity growth to which I now turn.

2.B Evidence on factor growth and productivity

Measuring TFP growth is a fraught topic depending on whether econometric estimates or growth accounting is employed and in each of the cases results depend on the specific assumptions about the underlying production function (Nelson and Pack, 1999). Thus any results that can be cited are subject to many caveats but TFP growth estimates provide a first approximation of effects of the performance of the economies. TFP growth rates do not map into the required supply and demand curves that allow the calculation of the relevant welfare triangles. If there is no TFP growth, or negative as in many cases for individual sectors (Ahluwalia, 1985), then clearly there can be no gains in producer surplus to offset both the presumptive large losses in consumer surplus stemming from higher prices of imports and the initial losses in productive efficiency as measured by high effective rates of protection. But absent detailed

[9] See the references in footnote 6 and the underlying studies supporting the summary volumes.
[10] Martin and Page, 1983.

estimates of supply and demand curves over time, examining TFP growth rates is useful in measuring the aggregate performance of the economies in question which was strongly affected by their attempt to foster industrial development.

There have been numerous efforts to assess the impact of industrial policies on TFP growth of individual sectors in the export promoting East Asian countries. The approaches have varied but most try to estimate the impact of specific policies such as tariffs and subsidies on individual sector TFP growth in a few countries, primarily Japan, Korea, and Taiwan and they have uniformly found no impact or a negative one.[11] These approaches have been criticized by Rodrik (2008) as difficult to interpret – roughly the more backward sectors may have received more protection - the amount of stimulus is endogenous - this is not a convincing evidence of the failure of IP. However, other tests that rely on different methods have also found a limited impact. Even if one grants that existing research has flaws and assumes that at least some of the past success in Japan, Korea, and Taiwan was attributed to industrial policy, its proponents in other regions, particularly Africa, need to take account of the many demonstrated failures of ISI.

Aggregate performance in measured factor accumulation and TFP growth are one gauge of the effectiveness of industrialization policies. Most countries that have attempted it have subordinated almost all development efforts to industrialization, what Michael Lipton termed the urban bias in development. Policies affecting other sectors included taxation of agriculture, neglect of productivity enhancing policies towards agriculture including R&D and extension services, price ceilings on food to ostensibly provide low cost food to industrial workers, higher prices of industrial goods adversely affecting the use of industrial inputs in both agriculture and services, and many others well known in the development literature. Thus, a first cut at the success of industrial policies across countries is a useful first step although there are many other reasons for poor aggregate performance.

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[11] Noland and Pack, 2003, Pack and Saggi, 2006, and Harrison and Rodriquez-Clare (2009) provide extensive surveys of the analytic and empirical literature.

Rates of growth of output per worker and the contribution to it of capital deepening, education deepening, and TFP are shown in Figures 3-5. The figures are based on the calculations of Bosworth and Collins, BC, 2003.[12] The three periods are those presented by BC, 1960-73, 1973-90, and 1990-2000. BC generate comparable figures for the growth of output (Q*), and the contribution of capital (K)*, quality adjusted labor force (L*), and education (E*) and utilize a growth accounting framework that assumes the underlying production function is Cobb-Douglas. The contribution of each factor is calculated by multiplying the measure of the growth of the factor by its putative elasticity of output with respect to the factor. Their data may not be entirely appropriate for the questions I will ask but they have the merit of consistent estimation across numerous countries. Additional issues, particularly the role of technical education will be discussed below. The countries examined are those non-Asian ones that practiced intensive ISI plus a few Asian nations that were quite successful without practicing the intensive selectivity of Korea and Taiwan.

These figures show that the Asian nations benefitted from high rates of factor accumulation, particularly capital. Part of the difference in growth over the entire four decades was due to the sustained growth in TFP in Asia in contrast to the lower levels and variability of TFP in the ISI countries (at the left and center of the figures), particularly in 1973-90. Even in the 1960-73 period, before the oil shocks of 1973 and 1979, Korea and Taiwan had greater capital accumulation and TFP growth than the ISI nations. Whereas 1960 to 1973 was characterized by sustained world growth, part of the continuing recovery from the Depression of the thirties and the Second World War, the 1973 and 1979 oil price shocks led to generally slower growth, particularly in the OECD countries which had strong feedback effects on the developing countries including the "lost decade" of the '80s in Latin America. The decade of the '90s saw a resurgence of OECD growth and a large increase in world trade. Japan is included for

[12] I thank the authors for their provision of the underlying spreadsheets used in their analysis which were also used in Noland and Pack, 2007. Rodrik, 2008, also uses the BC data with different time periods and utilizes broad regional aggregates rather than the performance of individual national exemplars of particular policies.

completeness though as noted above, it had experienced three quarters of a century of sustained industrial growth before the Second World War and many of the policies adopted by MITI were initially designed to return sectors to their prewar status.[13]

As can be seen in Figures 3-5, the countries pursuing ISI (on the left side of the figure) had lower aggregate growth of output per worker, $(Q/L)^*$, lower contributions from the growth in the physical capital-labor ratio, $(K/L)^*$ and lower growth in education-wage adjusted labor force $(E/L)^*$. Performance in Korea and Taiwan was particularly impressive in terms of $(K/L)^*$ but the Asian economies such as Indonesia, Malaysia, and Thailand that did not pursue intensive industrial policies also had very high aggregate growth. ISI countries had both lower capital accumulation and TFP growth. This pattern of slower growth in $(Q/L)^*$ and $(K/L)^*$ holds for all of the ISI countries through all three time periods though for a decade or so, a country may have contravened the general pattern. Note that the higher value for A^* in Latin America during the 1990s resulted from increasing capacity utilization as the recovery from the lost decade of the '80s unfolded.

The value of TFP growth is not that much greater in Korea and Taiwan than in other nations in all periods but cumulatively it was much better as they avoided the problems of 1973-90. This fact has of course been widely noted and given rise to a large literature on the method of calculating TFP growth and why the assumed Cobb-Douglas might not yield the correct results (Nelson and Pack, 1999, Young, 1995). However, even taking the estimates of A^* as a first approximation, what is surprising is that the Korean and Taiwanese TFP growth rates were not driven towards zero as their capital-labor ratios increased so rapidly. In both countries there had been limited experience with industrialization during the Japanese occupation.[14] Yet they were able to absorb a huge increase in capital-labor ratios without running into diminishing

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[13] For a thorough analysis of Japanese industrial policies see Komiya et al, 1988.

[14] See Ranis, 1979 on Taiwan (China) and Kuznets, 1977 on Korea.

returns. Clearly they were shifting to higher production functions utilizing imported knowledge as there was little domestic R&D until the 1990s (Pack, 2001).

The BC data are the most inclusive and comparable data available yet the results may understate the differences among the Asian and ISI countries. Two issues arise, namely, the measure of the contribution of education and the nature of the assumed production function. The education measure is years of education weighted by wage differentials, following the pioneering work of Denison. But this method assumes competitive labor markets which certainly was not the case in the ISI economies but was a not bad approximation in Korea and Taiwan. Other metrics of education achievement may be more relevant. Second, the production function used by BC is a standard Cobb Douglas. If instead one uses a CES or other more flexible form it is impossible to estimate TFP growth in the conventional way – the estimate of TFP depending on the bias of technical change and the elasticity of substitution which are impossible to estimate simultaneously (Diamond, et al, 1972). In the case of the Korea and Taiwan Richard Nelson and I argue that A^* is underestimated and the high value is attributable to technology assimilation from abroad, a question I return to in Sections 3B and 3C.

2.C Industrial Upgrading

The metrics used above to assess the success of earlier industrial policies might be construed as too narrow. Simply increasing the value added share of manufacturing might be an inadequate measure if the aim was to achieve a switch to higher technology sectors within manufacturing. An augmented measure might be justified on the grounds that some externalities benefitting other sectors might have stemmed from such promoted activity (though they should have manifested themselves in aggregate TFP growth). There are many measures one could use for industrial upgrading. For example, value added per worker in manufacturing would be one but it might reflect differences in the capital/labor ratio across countries rather than success in promoting higher technology sectors. Several proxies are available and I present several in Figures 6-8 for those countries for which the figures are available:

3. High-technology exports (% of manufactured exports)
4. Machinery and transport equipment (% of value added in manufacturing)
5. Information and Computer Technology (ICT) goods exports (% of total goods exports)[15]

With the exception of Brazilian exports of machinery and transportation exports, (reflecting primarily the exports of Embraer jetliners), the effort to upgrade has not been particularly successful. In all of these dimensions, countries that initially emphasized ISI as a selective industrialization policy did not achieve their ostensible objective of upgrading. Countries in Africa, Latin America, as well as India failed in their efforts to increase high technology manufacturing exports (Figure 6) or machinery and transport equipment production (Figure 7) - this despite India's efforts to mimic the Soviet Union in the production of machine tools and Brazil's early expansion of machinery production (Leff, 1968). Similarly, the export of information and computer technology (ICT) goods did not occur (Figure 8) though as will be discussed in Section 4 India had remarkable success in software exports. None of the other ISI nations evolved towards greater success upgrading despite intensive efforts.

The ISI countries all had policies designed to shift production towards high technology sectors but the implementation was not successful. No mechanisms were built into the system that would have forced local firms to improve their international competitiveness by threatening the withdrawal of various protective measures and this

[15] The data are taken from the World Development Indicators. The definitions are the following:
High-technology exports (% of manufactured exports)
High-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery;
Machinery and transport equipment (% of value added in manufacturing)
Value added in manufacturing is the sum of gross output less the value of intermediate inputs used in production for industries classified in ISIC major division 3. Machinery and transport equipment comprise ISIC groups 382-84;
ICT goods exports (% of total goods exports)
Information and communication technology goods exports include telecommunications, audio and video, computer and related equipment; electronic components; and other information and communication technology goods. Software is excluded

removed a key incentive to exploit international technology.[16] Moreover, even had they attempted this, the absence of required education levels would have militated against success in this endeavor. And the policies pursued in almost all countries led to the highest protection being accorded to consumer goods, next to intermediates, and lowest to producers' goods such as machinery. Thus, the attempt at upgrading was unintentionally undermined by the very design of the policies. If still other countries are added to the list of nations that attempted ISI, the results shown in Figures 6-8 would be replicated. Thus, the Asian nations held up as the paragons of industrial policy are hardly typical of the probable results of such a policy.

3. Was industrial policy decisive for Asian performance?

Figures 3-5 show that the proximate sources of difference in growth between the ISI countries and Korea and Taiwan are accumulation of physical and education capital and TFP growth. There are many characteristics of these countries that have been set out in a number of studies, most completely in the World Bank's The East Asian Miracle. The question of whether industrial policy *per se* or broader policies were responsible for these differences is now addressed.

3.a Capital Accumulation

Figures 3-5 showed that a large part of the rapid growth in Asia was due to capital accumulation. Most of this was domestically financed so that the determinants of high savings rates, particularly that of households, needs to be explained. Most research contends that once rapid growth got underway, standard models of permanent income combined with lags due to habit formation can explain much but not all of the high saving. (World Bank, 1993, Chapter 5). Further fillips to saving may have stemmed from positive real interest rates offered to savers, unlike those in the ISI countries which often had negative real rates of interest due to ceilings on nominal interest rates combined with high inflation. It would be difficult to attribute the high

[16] Compare Kim's (1997) account of a Korean firm's intensive efforts to master the technology of microwave ovens with Leff's (1968) account of the lackadaisical efforts in Brazil's machinery sector.

saving rate to selective industrial policy though it might be argued that had investment allocation been worse, rates of return would have been lower and would have reduced interest elastic savings rates. This has not generally been argued by proponents of industrial policy and certainly there have been no attempts at empirical verification of such a link. But for countries attempting to diversify their production structure, it would be difficult to infer from Korean-Taiwanese history any recipe to increase household savings rates. Obviously government saving could be increased by fiscal policy but this is not usually viewed as an aspect part of industrial policy rather than general macroeconomic prudence.

3.B Education

Korea and Taiwan, in comparison with the ISI nations, had more rapid accumulation of education (quality adjusted years) the measure used by BC to calculate the figures used in generating Figure 3-5. But important dimensions of educational achievement are not captured in such a measure, in particular the excellent performance of Asian students on international tests in math and science knowledge which measure the cognitive skills of the labor force rather than simply years of education. Test scores in math and science in internationally standardized tests[17] are set out in Figures 9A and 9B which convey the very different levels of achievement. Moreover these differences in scores at early ages anticipate differences in enrollment rates in universities in science and engineering faculties. For example, by the mid-‘50s, Taiwan had much greater enrollment in tertiary education than Brazil and three times the enrollment rate in science and engineering faculties. Similar differences prevailed between Korea on the one hand and Argentina, and India on the other. These cannot be viewed as the endogenous result of the growth in demand for such graduates as this was a period in which Korean and Taiwanese graduates were emigrating. But growing endowments of technically educated persons was an important source of supply response once economic policies were changed to encourage rapid growth in general.

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[17] For recent research on the role of cognitive skills in development see Hanushek and Woessmann, 2008.

These differences in cognitive skills suggest that the potential industrial competence both in terms of managers and workers was much greater in the Asian nations in general – not only Korea and Taiwan – and there was a larger potential supply response in the Asian nations than in the countries undertaking ISI when policies were instituted to foster growth. In the latter, industrial promotion may have been pushing on a string.

One reason for looking at high science and math skills is that these probably correspond more closely than simply years of education in explaining the success of Korea and Taiwan in implementing the rapid borrowing of foreign technology. A model of technology transfer suggested by Nelson and Phelps (1966) is particularly relevant. They posit that high levels of education are important for identifying and utilizing more advanced technology is particularly relevant.[18] (see the Appendix for a brief version of their model). They argue that where technology is rapidly evolving (or in our case is imported), learning about the existence of new processes, learning to use them when they are deployed, and staying abreast of complementary technological evolution requires the adaptability provided by high quality formal education. While all education is important for fostering civil society, science and math competence at an early age plus high enrollment in technical subjects in tertiary education are particularly important to productivity growth.

The benefit of high education achievement accrues not only when the technology in a given sector is changing but also when the sectoral structure of production is being altered as a result of a changing product mix (Schultz, 1975). If there is rapid accumulation of physical or human capital relative to unskilled labor, the composition of the industrial sector will change – the sectoral transformation envisioned by proponents of inducing industrialization may be contingent on the underlying skill structure of the economy and can't simply be brought about by changes that affect relative product prices and cost structures among sectors. Through this prism, the relatively poor

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[18] Their model has received renewed attention in the endogenous growth literature. See, for example, Aghion and Howitt, 1998, Chapter 10.

performance of ISI nations could be due not only to the lack of competitive pressure stemming from protection but to low levels of technical education and/or low inflows of foreign technology. The low technology inflow may in turn have been due to inadequate education in addition to the inability to finance it given low export earnings, a corresponding absence of demand by firms given little competitive pressure due to the protection regime, mismanaged macro policies, or the ideology often prevalent in ISI nations espousing technological self sufficiency. (see footnote 19 below).

So IP would have to be supplemented by a program that rapidly improves education quantity and quality. Again no one has made the claim that these high levels of education achievement were an outcome of IP rather than external to the effort though it can be argued that efforts to allocate capital to highly productive sectors, if they are successful, will generate higher returns to labor and thus encourage investment in education.

3.C The Role of International Technology Transfer

A major attribute of the Asian nations was their openness to international technology inflows. For poorer nations with low levels of domestic innovation, new technology is primarily imported rather than generated domestically. Some of the technology is embodied in material imports – intermediate manufactured inputs that incorporate new research such as semi-conductor chips and new machinery that incorporates improvements in speed, internal quality control mechanisms. Disembodied knowledge is obtained by technology licensing agreements and through foreign direct investment which brings in improved production practices and organization capabilities as well as marketing networks. Occasionally, knowledge transfers are the unpaid and unanticipated by-product of commercial transactions, for example, knowledge provided by OECD based retail purchasers of Asian exports. There are still other sources of ideas, for example, the use of non-proprietary information or reverse engineering and obtaining knowledge from nationals who have been educated abroad and who had been employed in firms in industrial countries for a considerable period.

Countries need not employ all of the potential vectors of new technology but they need to utilize at least some. During the 1950s Japan relied heavily on technology licensing while discouraging FDI (Ozawa, 1974, Nagaoka, 1989). In the 1960s and 1970s Korea also largely excluded FDI but used technology licensing, consultants, and imported equipment and intermediates as sources of technical advance (Hobday, 1995, Enos and Pak, 1987). Unlike the ISI countries, Korea and Taiwan were characterized by an openness to at least some (if not all) forms of foreign knowledge and actively pursued them. Almost all of these modes of international technology transfer were absent in the ISI nations that emphasized technological independence as an important component of their economic program, this view being derived from the then regnant Latin American paradigm of dependency theory.[19] Like Latin American nations, India was until the last two decades quite intent on technological independence. As one instance among many of the hostility of India governments to foreign firms, IBM was asked to leave the country in 1978.[20] The Reserve Bank of India set up fairly onerous regulation of technology licensing and limited royalty payments, similar to Latin American institutions such as the Andean Pact.

In the last two decades there has been an enormous amount of research on international technology transfer following theoretical development in the endogenous growth literature such as Grossman and Helpman (1991) and Rivera-Batiz and Romer (1991). Much of this research has sought to sort out the determinants of individual components of technology transfer and the effect of such transfers on the recipient economies including the impact on TFP growth as well as externalities from FDI. Almost all are cross country studies and subject to the standard problems that are familiar from testing cross country regressions of the determinants of growth.[21] In contrast, the following presents a small number of comparisons of technology transfers to countries

[19] A good critical source is Packenham, 1992. That "dependency theory" was not an academic curiosum can be gleaned from the fact that the canonical summary of it was written by the future President of Brazil, Fernando Henrique Cardoso. (Cardoso and Faletto, 1979.)

[20] Rajghatta, 2002, provides an account of this.

[21] Harrison and Rodriquez-Clare (2009) has an exhaustive survey of these studies and a clear discussion of their problems. Saggi (2002) also contains an excellent survey.

pursuing different strategies. The intent is to highlight using a few representative countries the very different orientation stemming from the strategies with respect to technology transfer and the likelihood that these differences were an important component in explaining success.[22] The main point is that an openness to and utilization of foreign technology was a key difference between Korea and Taiwan and the ISI countries and did not necessarily follow from a policy of stimulating individual sectors.[23] Such comparisons of course cannot establish that differences in technology transfers were a major component in the success of Korea and Taiwan – they are noted as one possible reason that the much faster rate of capital deepening was not accompanied by a rapid decline in the marginal product of capital.

Figures 10 and 11 show two indicators of embodied technology imports - imports of equipment, M_E, and imports of intermediates goods, M_{IN}, both as a share of GDP. Both measures are imperfect. In particular M_E is partly dependent on the investment/GDP ratio which is clearly greater in Korea and Taiwan than in the comparators. On the other hand, both nations were producing considerable amounts of machinery and intermediates yet were still importing a wide range of equipment and intermediates that presumably embodied large amounts of international knowledge (Coe and Helpman, 1995, Coe et al, 2006, Broda and Weinstein, 2006). At the other extreme, India was still dependent largely on its own technology, even in 2002, a decade after the liberal reforms of 1991. Although the data in Figures 10 and 11 begin in 1990 and are on an internationally comparable basis, data from Korean and Taiwanese data sources show these trends had much earlier origins.

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[22] There is also a large case study literature that analyzes at the firm level the process of technology identification and its assimilation into the production routines of firms. This literature, like that of cross country studies, allows no definitive conclusions about the efficiency augmenting effects of technology transfer. For a detailed review see Evenson and Westphal, 1994. A comparison of the insights to be obtained from cross country econometric estimates versus case studies is discussed by Pack, 2005.

[23] Nelson and Pack (1999) suggest that a shift of labor from lower to higher productivity firms was of importance in Korea and Taiwan. Eliminating such gaps in Korea and Taiwan, partially dependent on imports of knowledge (including consultants from Japan) undoubtedly played a role in aggregate TFP growth.

Two of the major sources of disembodied knowledge are FDI and technology licensing agreements. Korea actively discouraged FDI until the late '90s but utilized technology licensing agreements. Taiwan was similar but liberalized FDI a bit earlier. Cross country data on FDI as indicators of technology transfer are not useful insofar as they include investment in minerals, mining, and tourism whereas the critical sector for our purposes is knowledge transfer in manufacturing. Technology licensing payments are a better measure of such transfer and are shown in in Figure 12A for 1980 and 1990. As late as 1990, Brazil, the most technologically advanced of the ISI countries had a small fraction of Korean payments. Given that technology licensing agreements typically involve payments by the licensees for at least 10 years, the figures for each year provide a measure of the cumulative value of agreements in the prior decade. More generally, Figure 12B shows that many Asian countries were much active in technology licenses South Asian and Latin American nations, the differences diverging even more after 1990. The levels depicted in Figures 12A and 12B roughly correspond to qualitative studies of individual countries on the role of licensing in technology transfers (Evenson and Westphal, 1995)

Moreover, such indicators omit the many measures taken by the Asian countries in the sixties and seventies to identify and absorb technology. (Enos and Pak, 1987, Hobday, 1995, Pack, 2001). Having identified and purchased equipment or technology licenses, firms did not immediately jump to the best practice production function that characterized firms in the OECD nations. The accumulation of knowledge and experience was necessarily slow and involved a long sequence of learning, trial and error, and considerable investments in these activities. Countries pursuing ISI did not in general partake of such activities as firms were assured of profits because of government protection in the domestic market. But even in firms that are export oriented the augmentation of productivity will inevitably be slow.[24] There is nothing inherent in the strategy of promoting individual sectors that militates in favor of a simultaneous policy of encouraging technology inflows. While LA and India favored

[24] An excellent account of learning in Korean manufacturing is given by Kim, 1997.

specific sectors, there was no complementary attempt to encourage technology inflows. Moreover, as shown above education achievement was low, so that it would have been difficult in any case to pursue such a policy. Identification of the relevant foreign technologies and their successful absorption would have required the simultaneous pursuit of more and higher quality education, something that did not occur.

4. The Indian software sector

In assessing the success of ISI all of our measures of successful technological upgrading have so far been limited to manufacturing. But if the purview is extended to high technology service exports, Figure 13, India is exceptional – it has much greater dollar exports than any of the East Asian manufacturing exporters as well as the other ISI countries. Was this due to government initiated policy? The short answer is no - the outcome reflected (a) the existence of the Indian Institutes of Technology begun in 1946, which provided broad engineering and science training but whose curricula were established well before there was a separate software sector and (b) a serendipitous set of external demand shocks in the 1990s.

In the 1980s there were a growing number of graduates at levels from the Indian Institutes of Technology as well as proprietary post secondary technical schools. Almost all of the students trained in programming had been educated in English. There were 70,000 to 85,000 computer science graduates every year. Many Indian graduates also had a second university degree or post-graduate degree from the United States or the United Kingdom, often in computer technology. A major increase in demand for IT services came from two serendipitous events. In the 1990s the ratio of world prices for programming services relative to those in India increased due to a global shortage of programmers as a result of the demands for solutions to the anticipated Y2K problem.

Businesses in India capitalized on this opportunity by setting up firms that were essentially employment agencies. Indian software programmers were hired by local firms on behalf of clients in the United States and other nations on short-term contracts (either for a fixed period of time or on a project basis) to provide onsite services. 'Bodyshopping', as this practice was called, became the predominant mode of Indian software exports because the development work was performed on the client's premises, saving software firms the high costs of acquiring computer hardware. NASSCOM, the Indian software trade association reported that the software sector earned $2.5 billion from Y2K billing from 1996 to 1999, a critical period in the growth of the industry. As late as 1988 annual software exports had been less than $200 million but had risen to $3.6 billion by 1998, amounting to over 10 percent of total Indian exports.

Indian software firms also benefited from another instance of good fortune, the countries in the EU moving to adopt the Euro. Many Indian software professionals were actively involved in adapting existing computer systems and databases to accommodate the Euro. Between 2000 and 2002, it is estimated that India earned approximately $3 billion in revenues from these Euro-related IT projects (Rajghatta, 2001). Clearly a contributory factor was the low relative level of programming costs in India that conferred a Ricardian comparative advantage in some sub-sectors of software. No government industrial policy could have foreseen and acted upon the demand generated by Y2K and the Euro. The government's main contribution had been to provide high quality post secondary education.

Another "accidental" factor was the large number of expatriate Indian IT professionals located in Silicon Valley who had emigrated in the 1950 to the 1980s because of a lack of opportunity in India. In 1998 9% of the high technology firms were led by Indian CEOs.[25] Many of them helped to convince large American firms to establish operations in India.[26] Foreign direct investment accounted for a large percentage of early investment in the Indian sector. For example, in 1996, foreign companies accounted for 70% of the investment in software development in Bangalore.[27] And this contribution understates the total impact. Texas Instruments (TI),

[25] James, 2000.
[26] Saxenian, 1999.
[27] The Economist, 1996.

the first foreign firm to establish an offshore software facility in Bangalore in 1984 after IBM's departure in 1978, augmented Bangalore's inadequate land-based telecommunication infrastructure by investing in its own satellite communications network in conjunction with Videsh Sanchar Nigam (VSNL), the government's overseas communication agency[28]. Some of TI's lines were later leased to other software firms, enabling them to expand their India-based operations instead of relying solely on onsite services abroad. Until the government built software technology parks in the 1990s linked to earth stations and other telecommunications infrastructure, TI's satellite network remained an important component in the development of software exports.

How does this experience of a very successful sector square with arguments advocating industrial policy? All of it was privately initiated, governments at various levels becoming involved only after the success of the sector was evident. The industry expanded on the basis of comparative advantage and never needed any protection. Indeed, one characteristic of the software sector was that its inputs, largely downloads from satellites and its output, uploaded to satellites, could not easily be taxed as intermediates had been during the ISI period. The large agglomeration of firms in Bangalore arose spontaneously without government direction. Foreign contracts rather than government subsidies provided the basis for international exploration of markets. There is no evidence of government initiation or preference though at a late stage the government provided some benefits that in effect ratified and supplemented earlier private measures.

5. Historical Legacy

Assessments of the impact of industrial policies typically ignore history and complementary efforts in many dimensions such as physical infrastructure and education. Rather they utilize a context free analysis in which it is assumed that changes in relative prices automatically produce a set of responses that are not conditioned by factors other than the policies being assessed. Most comparative statics

[28] The telecommunications industry in India is state-controlled, hence the need for TI to procure the services of VSNL instead of a private firm.

in microeconomics makes this assumption. But the poster children for such policies, Korea and Taiwan, had many historical developments, particularly under Japanese colonialism that made them more capable of responding to economic incentives including the building of high quality roads. Taiwan had benefitted from the relocation from Shanghai in 1949 of many managers and owners of textile firms (Ranis, 1979, Dahlman and Sananikone, 1997). And the quantity and quality of education and infrastructure were vastly augmented while the countries pursued industrial policies in the 'sixties through the 'eighties.

The experiments in ISI in other nations did not benefit from such legacies nor did governments augment the infrastructure present after WWII or encourage tertiary education with an emphasis on science and technology or pursue stable macroeconomic policies. In addition, both Korea and Taiwan had experienced major institutional changes such as land reform, urged by the U.S. that led to a virtual elimination of local elites that might have obstructed industrial growth (Olson, 1982). In contrast, Latin America, India, and later African nations such as Tanzania (which followed a "basic industries" strategy) did not have the agreement of most interest groups on the primacy of aggregate economic growth.

Thus, even assuming that government officials could presciently identify sectors with latent comparative advantage, there are many additional measures that need to be undertaken simultaneously even though the countries have limited administrative capacity and limited finances. If industrial policies are to be urged upon countries that have yet to undergo structural transformation, it needs to be shown that the decisive characteristic of Korea and Taiwan was industrial policy rather than all of the growth promoting changes that were implemented alongside industrial policy.

This suggests one of the problems facing efforts in other less industrialized nations to achieve structural transformation using some form of industrial policy. The assumption of such analyses is that the limited size of manufacturing, especially in

Africa and the Middle East represents largely a limited entrepreneurial base.[29] But the lack of activity could just as well reflect the absence of the necessary infrastructure and quality education.[30] Many analyses have recently demonstrated that even if firms and industries reduce their costs, their international competitiveness suffers from off-factory cost increasing factors such as poor road transportation and inefficient ports and airports.[31] As one of many types of evidence, in 2005 the cost of preparing a container for export was $780 in Korea, $1,325 in Argentina, and $1,980 in Kenya (World Development Indicators). Such differences reflect both investments in port infrastructure as well as the regulatory framework. It may not be an accident that the most dynamic sector in India, software, was one that did not depend on complementary publicly provided services except for electricity. The downloading and uploading of new code to a satellite, privately provided by a foreign company, avoided the obstacles posed Iby deficient public sector inputs.[32]

The empirical identification problem of sorting out the effect of industrial and other policies is formidable. All of these policies in Korea and Taiwan were elements of a package that could not easily have been disassembled. High investment rates would have run into severely diminishing returns absent high TFP growth policies in turn was made possible by the growing technical education and the resulting ability to tap international technology to move to a higher production function. Had marginal returns to capital not been high, there presumably would have been lower saving and investment rates as capital inflows were a small source of investment funding. Export

[29] For a discussion of the problems of Middle Eastern nations in fostering manufacturing see Noland and Pack, 2007, particularly Chapter 9. For discussions of the African economies see Lin and Monga, forthcoming and Page, 2009.

[30] A quite complete catalog of the problems in Africa is contained in Page, 2009

[31] Lin and Monga, 2010 note the critical importance of infrastructure in the early development of the U.S. and other OECD countries The importance of infrastructure and a variety of ex factory cost= raising features is shown in a study by the World Bank of African industrial development (Page and Go, 2008) and a paper on Egyptian export efforts by Magder, 2005.

[32] Consider whether labor-intensive Korean clothing and sporting goods firms could have succeeded in the '60s and '70s had high shipping costs to Seattle and San Francisco been made even worse by a poor internal transportation and port system? At a later date, could Samsung electronics and Hyundai cars been efficiently produced with intermittent electricity supplies and a costly transportation system.

growth was important as a source of demand as it precluded the need for production to be sold along a downward sloping domestic demand curve for individual products and a small but growing share of the huge international market allowed for simpler macroeconomic management. Most of the Asian nations were characterized by several of these features. Thus many things in Korea and Taiwan were done right simultaneously. It is highly problematic to single out selective protection as the critical element among all of these elements. Any country considering embarking on a similar program would have to be sure of getting all of these requisites in place initially and then maintaining the stance over time. The experience of the large numbers of ISI nations that failed to do so is not reassuring to current prospects for industrial policy, particularly in Africa to which I now turn briefly.

6. Lessons for the least industrialized countries

Many of the poorest economies undoubtedly suffer from all of the market failures that are invoked to justify industrial policies to redress them. In principle, many interventions could be welfare improving. But the preceding sections suggest some important perspectives. First, many of these nations suffer from low capital accumulation and low education level levels and quality. Expanding the number of the poorest economies shown in Figures 3-5 and 9 would reinforce the prevalence of low investment rates and low education achievement. This would imply that before considering fine tuned instruments, simply raising national saving and investment rates and providing more and higher quality education would be top priorities. Many potentially useful interventions have been put forward in recent papers. (Page, 2009, Lin and Monga, forthcoming, Rodrik, 2006). But even if such policies could be designed and implemented without being captured by political groups,[33] questions arise about

[33] The bureaucracy charged with implementing EP in Korea and Taiwan was largely insulated from the political pressure of firms though obviously there were exceptions. At the same time, the government possessed substantial knowledge about individual firms as the stimulus efforts received careful government monitoring of firms, particularly of their exports, and there were constant interactions among officials and private sector executives. (Jones and Sakong, 1980),

their productivity in the absence of the basics such as infrastructure and education usually provided by governments.

Moreover, even if many of the lessons of Asia from high saving to infrastructure are followed, the experience of Korea and Taiwan in the mid-‘60s is going to be difficult to replicate currently for several reasons. First, the great growth in international trade and the generation of huge industrial agglomerations particularly in China, makes it difficult for new entrants to compete. Second, over the next decade there will be a major international macroeconomic adjustment - a reduction in excess demand by a few countries, notably the U.S., and a concomitant increase in domestic absorption of GDP in a number of surplus countries in Asia as well as Germany. (Blanchard, 2008). To achieve a share of the (relatively) contracting U.S. imports will not be easy nor will it be easy for non-Asian emerging markets to penetrate the Chinese and other Asian markets as they redirect their own production toward domestic uses. This is not to say that world exports will be stagnant, simply that rates of growth that prevailed from the 1960s to 2007 are unlikely to continue.[34]

There is an obvious response to this updated version of the export pessimism, namely, it is always possible to find a niche in which a country may achieve low costs and thus penetrate advanced markets. The standard theory of comparative advantage would argue that countries could export goods (or services) in which they had either a technological advantage or relatively favorable endowments. Mangoes from Peru and wines from Chile, South Africa, and Argentina are examples.[35] But as one shifts thinking away from natural resource based commodities and considers either industrial production or services, the issues become more complex. Consider the industrial sector

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26. After a hesitant resumption of world trade after the great recession, China's exports increased by 46 percent in February, 2010 compared to the preceding February (Lafraniere, 2010). This implies a massive absolute increase in exports of all types, Chinese firms taking advantage of already established ties with western importers. The magnitude of Chinese growth underlines the obstacles facing nations trying to diversify and upgrade by entering international trade.

[35] Chandra (2006).

options facing a typical relatively poor country with low capital and technology. How could it identify a niche and will this work? Which sectors are candidates for export expansion, ignoring for the moment the precise policies that might be pursued?[36] Earlier sections note that there are many determinants of potentially competitive exports: the national economic environment including real exchange rates, tariffs on imports used in export production, infrastructure including roads, electricity supply, port facilities, and firm level technological knowledge Governments intending to foster development of individual sectors face a formidable set of knowledge requirements such as predicting the rate of TFP growth in individual sectors within a country and in comparable foreign sectors.[37]

While a few individual emerging market manufacturers might be able to identify a product in which they possess a comparative advantage, most are likely to be caught between the high technological capacity in the OECD nations and the mass production capabilities and agglomeration economies that have developed over the last four decades in China and other Asian nations, and more recently in some parts of Eastern Europe. Extant mass production and the close links already established between international production and purchasing networks are particularly important. Moreover, China will not quickly cede its labor intensive sectors to newcomers – there are still hundreds of millions of residents largely in the western part of the country who have not benefited significantly from its growth. The focus on encouraging still more exports of labor intensive products is one reason underlying its unwillingness to allow an appreciation of the reminbi. As wages rise in the already richer regions, firms have the option of moving west within the country rather than establishing subsidiaries in other nations. Such a move would bring scores of millions of currently low wage workers into the international labor force.

Technical production competence, higher managerial and worker productivity, even if achieved, are not sufficient to insure exports. Firms attempting to enter export

[36] For a discussion of the difficulties of identifying new products see Pack and Saggi, 2006. Also see Ghani, 2010.

[37] Pack and Saggi (2006) have a list of fifteen such knowledge requirements.

markets cannot assume that realizing low cost is sufficient to assure foreign sales. There is no guarantee that firms in a new potential exporting nation will be on the radar screen of lead firms in international supply chains such as Walmart in purchasing or Dell in production. The existence of supply networks imposes a significant challenge to emerging market firms that are not already embedded in such a network. Similarly, it is likely to be difficult to compete with many nations in services, especially ones that have recently received great attention such as IT services and call centers. A labor force that is relatively large, relatively low paid yet skilled in international languages and computer skills is necessary and most African and Middle Eastern countries are not so endowed.[38]

Given that new producers are will be caught in a narrow squeeze in product choice between the technologically advanced OECD and a few other nations at the upper end of the technology continuum and large low cost producers with considerable production experience and agglomeration economies, poorer nations have few strategic choices for encouraging particular export sectors or individual products. It is easy to say that with a better investment climate, improved infrastructure, better educated workers and so on, entrepreneurs will find their way into international markets but this is not a good bet. Just as garage innovators like Edison have given way to huge industrial research laboratories such as Samsung's, it seems likely that even entering "simple" product areas has become problematic given the rapidity of product evolution and very rapid decreases in profitability.

In some countries, the old balanced growth model stemming from the big push with its implication that industrial firms can find a local market is potentially of importance. Many countries continue to import simple industrial products in which local firms, once begun, would have a cost advantage due to transportation costs (Lin and Monga, forthcoming). The absence of such production is one of the more puzzling phenomena in development but is quite clearly an important empirical fact. Of course, even the generation of local production for of skill, low technology products to be sold to a growing rural market is far from assured but it might offer the possibility of

[38] For an intensive examination of the services sector in Southeast Asia and the problem of identifying appropriate service sectors for expansion see Ghani, 2010.

industrial diversification – if all of the requisite parts fell into place. Paradoxically, diversification of the manufacturing sector may require measures to improve incomes in the non-industrial rural sector, a point underlined four decades ago in the Lewis-Fei-Ranis model. These include measures such as rural road construction and efforts to improve farm productivity. But the manufactured goods, if they were produced, sold to rural residents are not those likely to enter into international trade immediately. Assuming productivity growth, they could however become candidates for exporting.

For economies that are late to the effort to diversify and upgrade their production structure, 2010 is much different than the 1960s or 1970s. Many countries and their firms have accumulated a huge pool of skills ranging from production to marketing. Much of international trade is in the hands of large firms that organize consumer or producer networks and it is difficult to become part of these organizations. Simply building up production capacity of a few firms in one sector is unlikely to be a successful strategy. However understandable the temptation for foster growth through activist policies, the historic record suggests that going back to basics is the first order of business.

Appendix

The role of education can be formalized following Nelson and Phelps. Firms in LDCs operate with a technology level equal to $A(t)$ in period t. Their peers in industrial countries using technology $T(t)$. The rate at which the DC technology is introduced into the LDC depends on the level of human capital, h, and is

$$A'(t)/A(t) = \alpha(h)[(T(t)- A(t))/A(t)]. \qquad (1)$$

The extent to which local LDC technology improves is a positive function, $\alpha'(h) > 0$ of the level of human capital and proportional to the magnitude of the difference between current and "best practice" technology. As the technology T(t) does not have to be invented, the potential productivity gain from the transfer of this technology is the potential benefit of relative backwardness using Gerschenkron's term. Assume that the DC technology improves each year by φ percent so that

$$T(t) = T_0 e^{\varphi t} \qquad (2)$$

Given (1) and (2), the underlying differential equation implies that the equilibrium path of technology of a firm is

$$A(t) = [\alpha(h)/(\alpha(h) + \varphi)]\, T_0 e^{\varphi t}. \qquad (3)$$

The level of technology realized by an LDC firm at a moment in time will thus be higher: (1) the greater its ability to deal with new technologies as a result of the presence of qualified individuals on its staff; (2) the larger the inflow of technology to the firm in the form of new equipment, new material inputs, new knowledge obtained from consultants, licensors, and foreign owners. Unlike formulations which treat education or purchases of knowledge as conventional inputs in the production function,

(3) implies that human capital will have no effect on the level of output obtained with conventional inputs unless $\varphi > 0$ which can only occur if new productive inputs are introduced, (3) being constant if $\varphi = 0$. The level of technology characterizing a firm will evolve along (3) and depends solely its own level of h and the rate of technical progress in the DCs that becomes available to the LDC firm. If foreign exchange shortages or arbitrary labor market rules prohibit some forms of technology imports that reduce the inflow of new knowledge, the benefit conferred by h is reduced. A(t) is also affected by the large number of policy interventions, P, characteristic of the ISI countries that reduce the level of productivity by encouraging rent seeking rather than a search for efficient technologies. Thus (3) can be rewritten as

$$A(t) = P[\alpha(h)/(\alpha(h) + \varphi_F)]\, T_0 e^{\varphi_F t} \qquad (4)$$

The term φ_F measures the firm-specific rate at which new technology becomes available. The idea that government interventions and other firm and country specific factors can depress the growth of firm productivity is captured by the assumption that $\varphi_F < \varphi$.[39] This might stem, for example, from regulations that limit expenditures on technology licensing payments so that a firm cannot purchase a potentially useful technology. The import of foreign technology allows local firms and nations to approach world best practice. Countries embarking on a structural transformation would have to pursue high quality as well as quantity of education to identify, modify, and productively absorb such knowledge. Although the highly educated labor force within a country may generate some purely indigenous innovations, they are likely to be less productive than if they are able to utilize their talents on a proven body of knowledge that is being introduced into the country for the first time. Local R & D inevitably has failures whereas gaining a mastery of technologies that are known to work in other countries has few dead ends.

[39] Parente and Prescott (2000) explore such mechanisms in detail.

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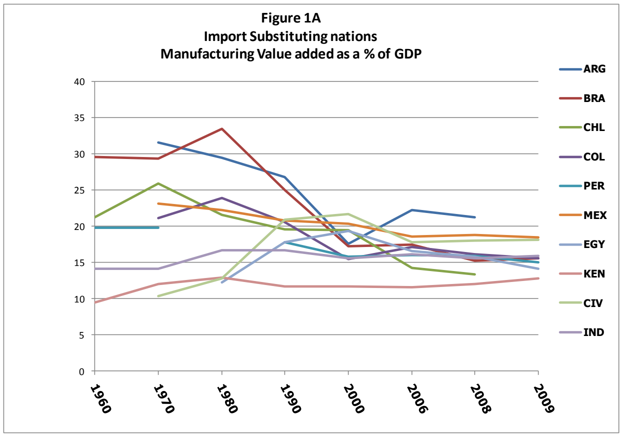
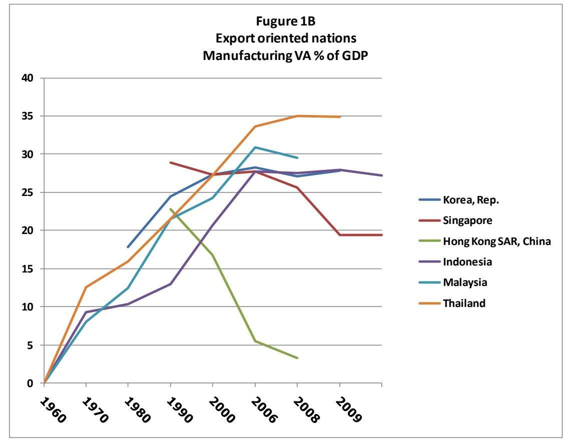


Figure 1A
Import Substituting nations
Manufacturing Value added as a % of GDP
40
35
30
25
20
15
10
5
0
1960
1970
1980
1990
2000
2006
2008
2009
ARG
BRA
CHL
COL
PER
MEX
EGY
KEN
CIV
IND


Fugure 1B
Export oriented nations
Manufacturing VA % of GDP
40
35
30
25
20
15
10
5
0
1960
1970
1980
1990
2000
2006
2008
2009
Korea, Rep.
Singapore
Hong Kong SAR, China
Indonesia
Malaysia
Thailand

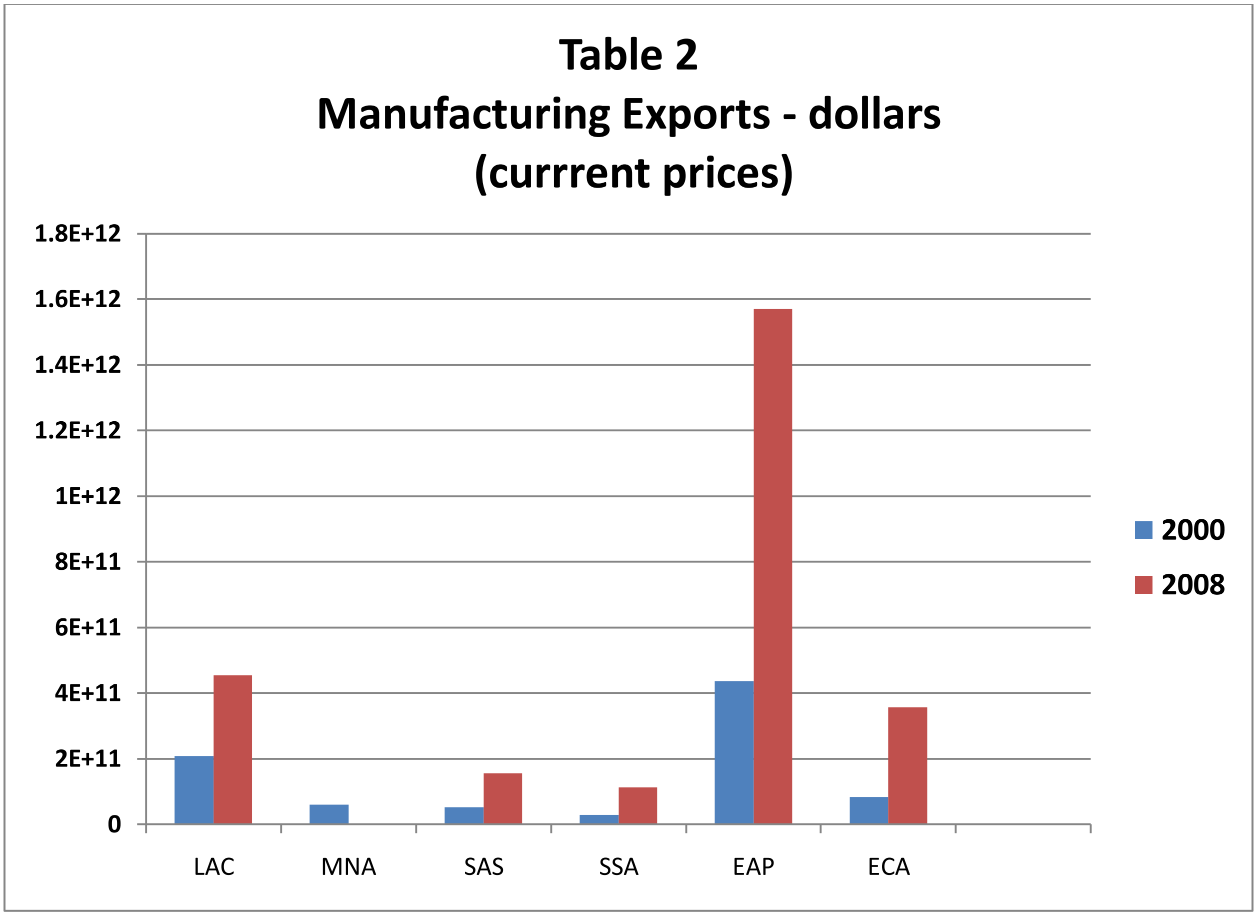


Table 2
Manufacturing Exports - dollars
(currrent prices)
1.8E+12
1.6E+12
1.4E+12
1.2E+12
1E+12
8E+11
6E+11
4E+11
2E+11
0
LAC
MNA
SAS
SSA
EAP
ECA
2000
2008

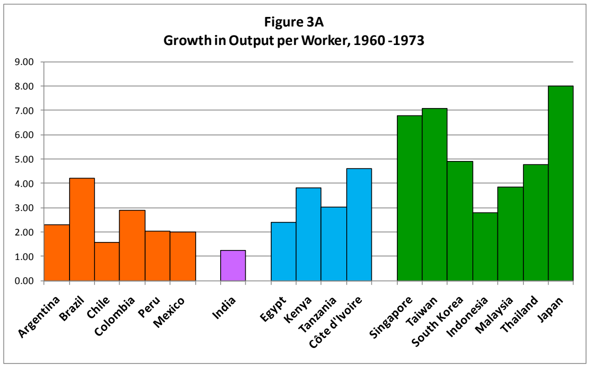


Figure 3A
Growth in Output per Worker, 1960 -1973
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Argentina
Brazil
Chile
Colombia
Peru
Mexico
India
Egypt
Kenya
Tanzania
Côte d'Ivoire
Singapore
Taiwan
South Korea
Indonesia
Malaysia
Thailand
Japan

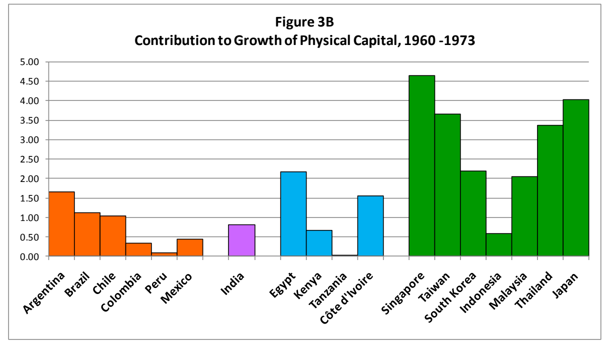


Figure 3B
Contribution to Growth of Physical Capital, 1960 -1973
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Argentina
Brazil
Chile
Colombia
Peru
Mexico
India
Egypt
Kenya
Tanzania
Côte d'Ivoire
Singapore
Taiwan
South Korea
Indonesia
Malaysia
Thailand
Japan

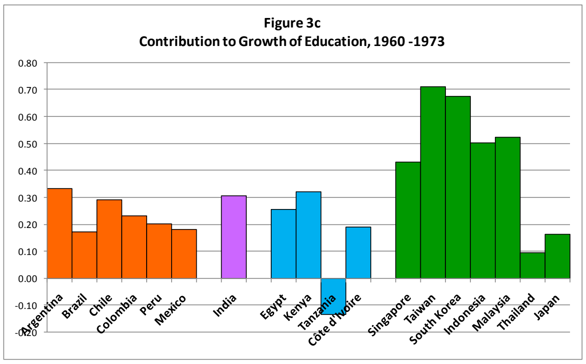


Figure 3c
Contribution to Growth of Education, 1960 -1973
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
Argentina
Brazil
Chile
Colombia
Peru
Mexico
India
Egypt
Kenya
Tanzania
Côte d'Ivoire
Singapore
Taiwan
South Korea
Indonesia
Malaysia
Thailand
Japan

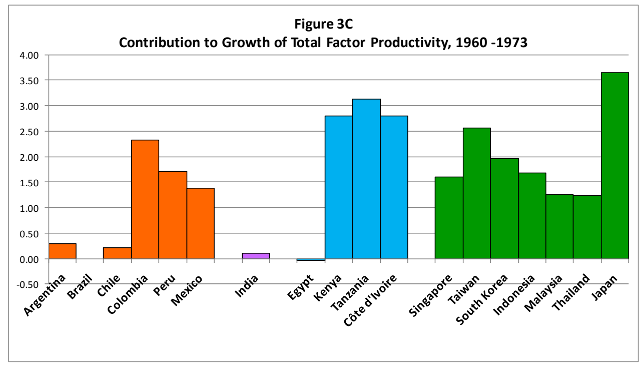


Figure 3C
Contribution to Growth of Total Factor Productivity, 1960 -1973
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
Argentina
Brazil
Chile
Colombia
Peru
Mexico
India
Egypt
Kenya
Tanzania
Côte d'Ivoire
Singapore
Taiwan
South Korea
Indonesia
Malaysia
Thailand
Japan

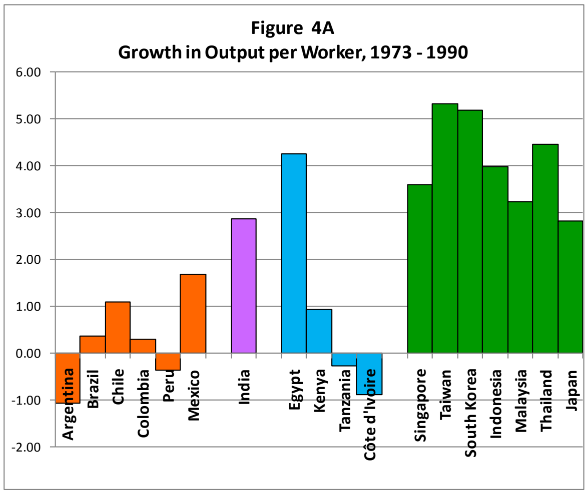


Figure 4A
Growth in Output per Worker, 1973 - 1990

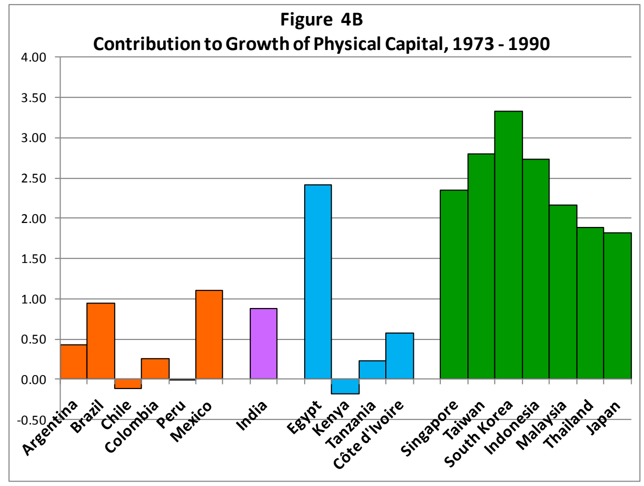


Figure 4B
Contribution to Growth of Physical Capital, 1973 - 1990

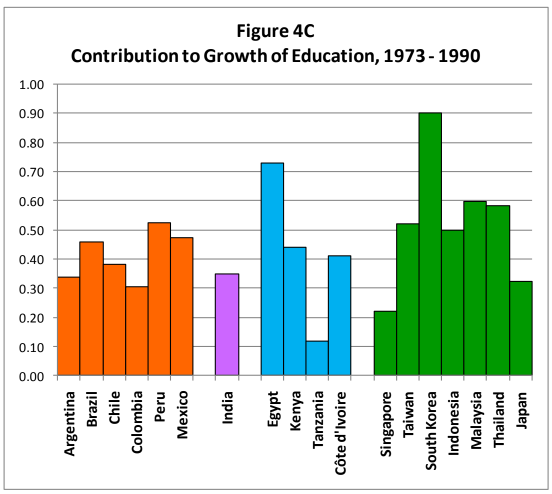


Figure 4C
Contribution to Growth of Education, 1973 - 1990

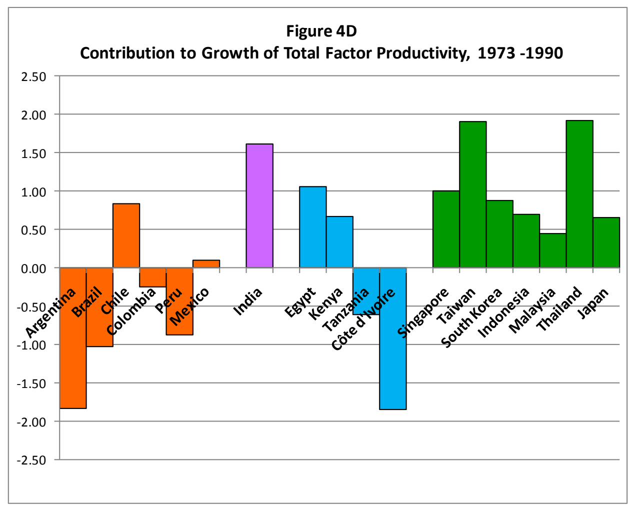
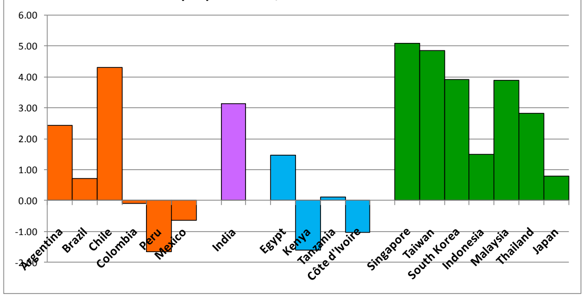


Figure 4D
Contribution to Growth of Total Factor Productivity, 1973 -1990

Figure 5A
Growth in Output per Worker, 1990 - 2000



Figurre 5B
Contribution to Growth of Physical Capital, 1990 - 2000

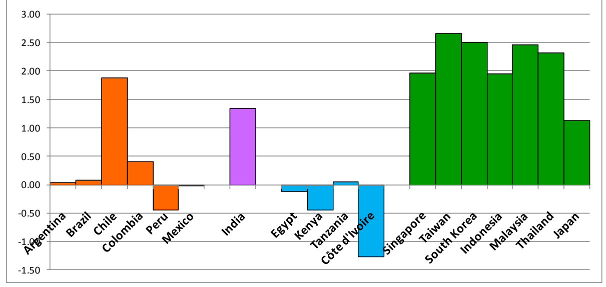
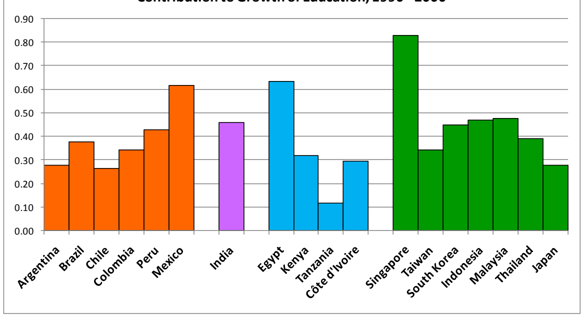
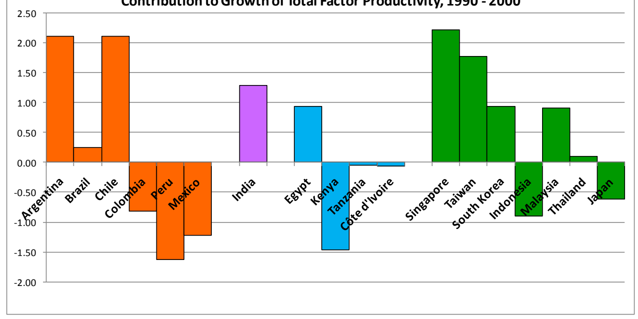


Figure 5C
Contribution to Growth of Education, 1990 - 2000



Figurre 5D
Contribution to Growth of Total Factor Productivity, 1990 - 2000



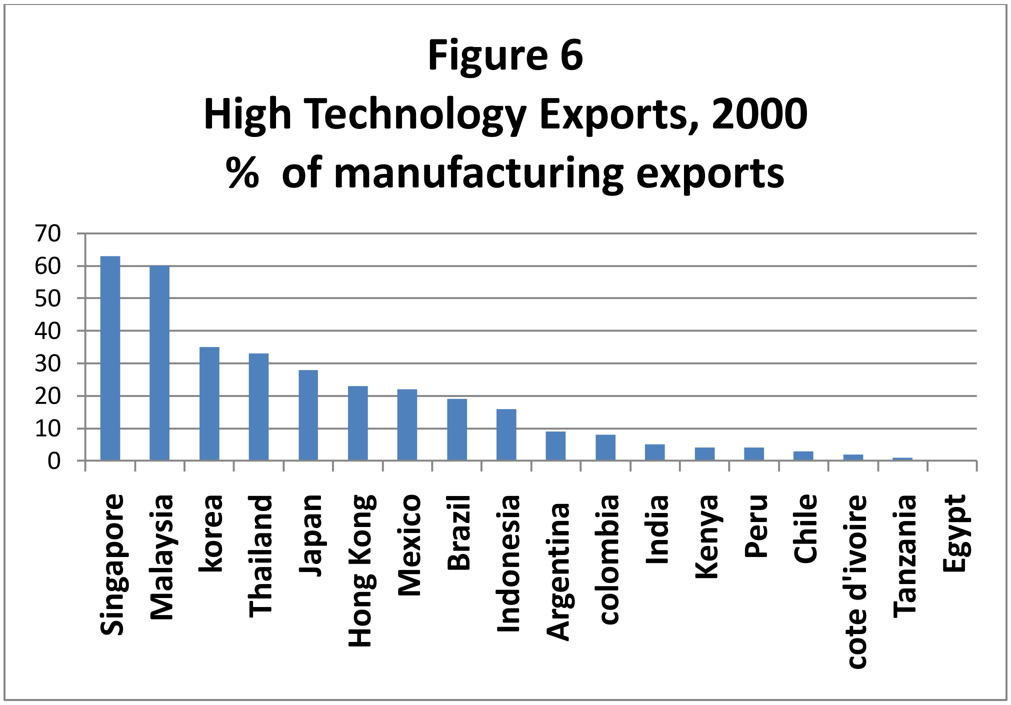


Figure 6
High Technology Exports, 2000
% of manufacturing exports
70
60
50
40
30
20
10
0
Singapore
Malaysia
korea
Thailand
Japan
Hong Kong
Mexico
Brazil
Indonesia
Argentina
colombia
India
Kenya
Peru
Chile
cote d'ivoire
Tanzania
Egypt

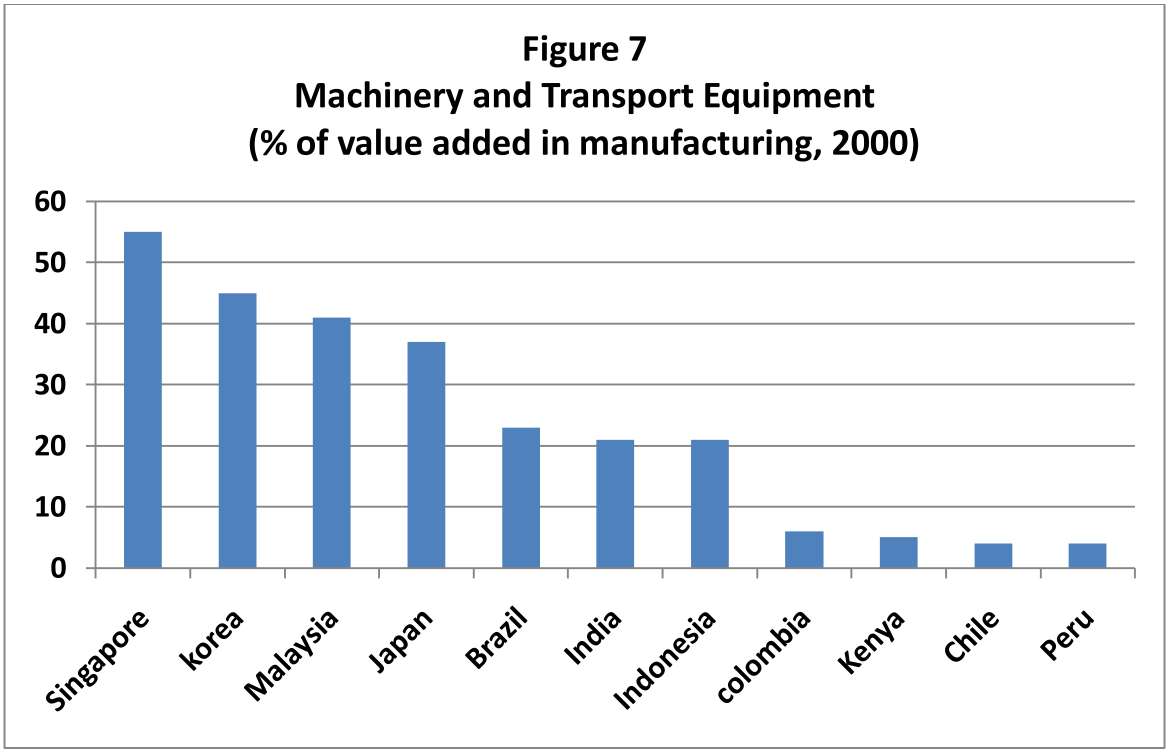


Figure 7
Machinery and Transport Equipment
(% of value added in manufacturing, 2000)
60
50
40
30
20
10
0
Singapore
korea
Malaysia
Japan
Brazil
India
Indonesia
colombia
Kenya
Chile
Peru

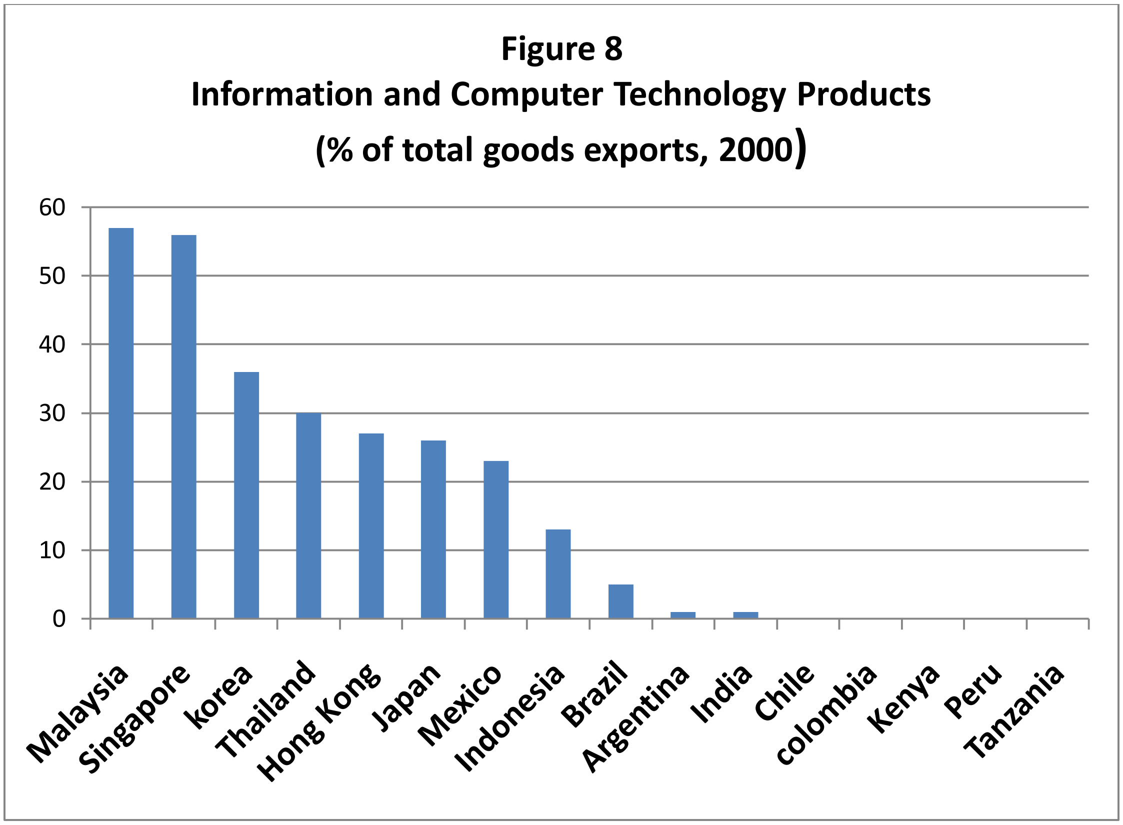


Figure 8
Information and Computer Technology Products
(% of total goods exports, 2000)
60
50
40
30
20
10
0
Malaysia
Singapore
korea
Thailand
Hong Kong
Japan
Mexico
Indonesia
Brazil
Argentina
India
Chile
colombia
Kenya
Peru
Tanzania

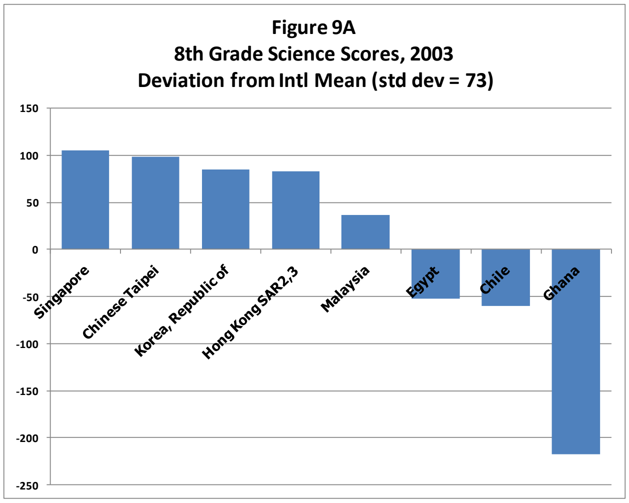


Figure 9A
8th Grade Science Scores, 2003
Deviation from Intl Mean (std dev = 73)
150
100
50
0
-50
-100
-150
-200
-250
Singapore
Chinese Taipei
Korea, Republic of
Hong Kong SAR2,3
Malaysia
Egypt
Chile
Ghana

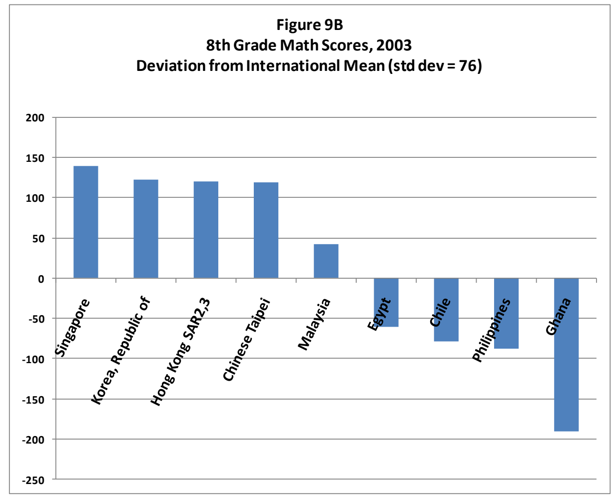


Figure 9B
8th Grade Math Scores, 2003
Deviation from International Mean (std dev = 76)
200
150
100
50
0
-50
-100
-150
-200
-250
Singapore
Korea, Republic of
Hong Kong SAR2,3
Chinese Taipei
Malaysia
Egypt
Chile
Philippines
Ghana

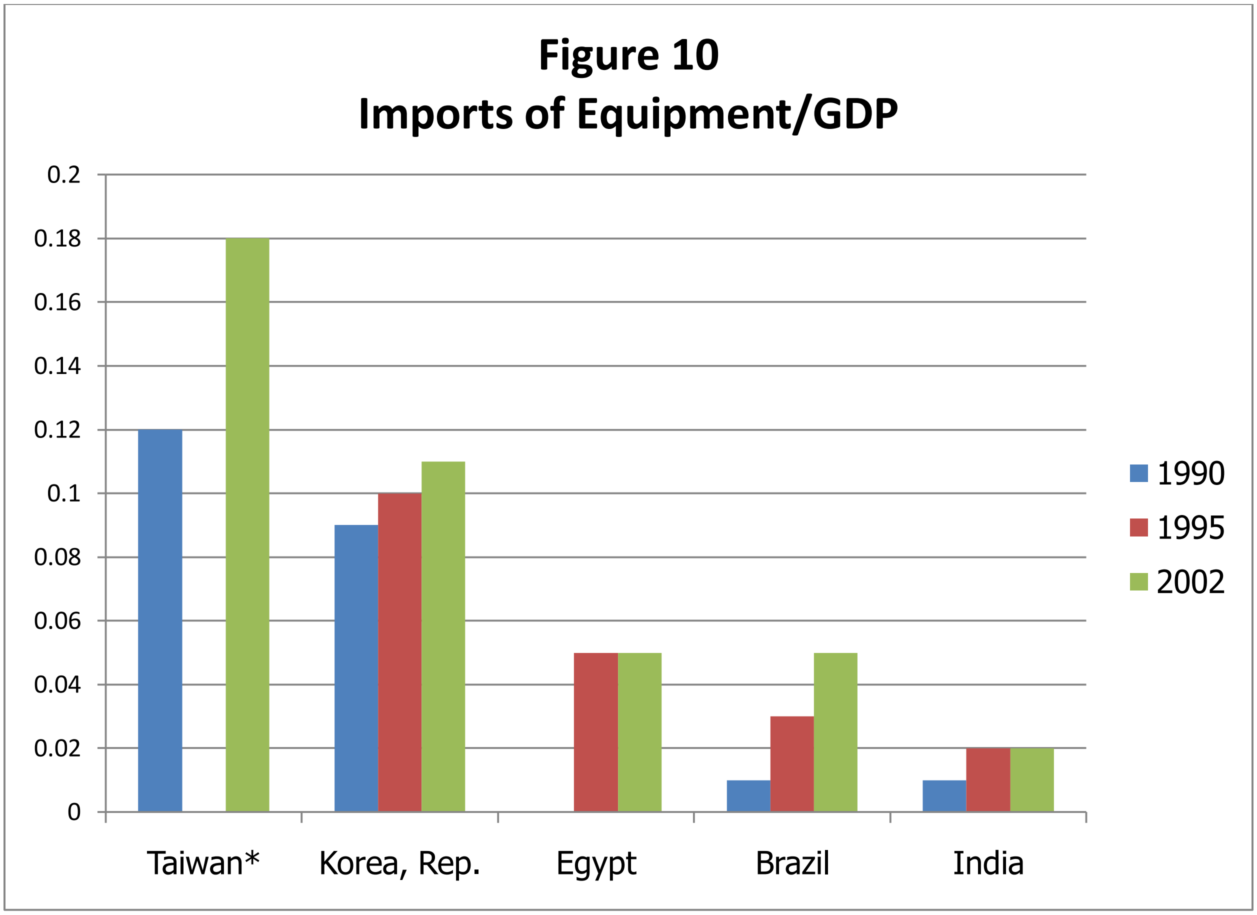


Figure 10
Imports of Equipment/GDP
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Taiwan*
Korea, Rep.
Egypt
Brazil
India
1990
1995
2002

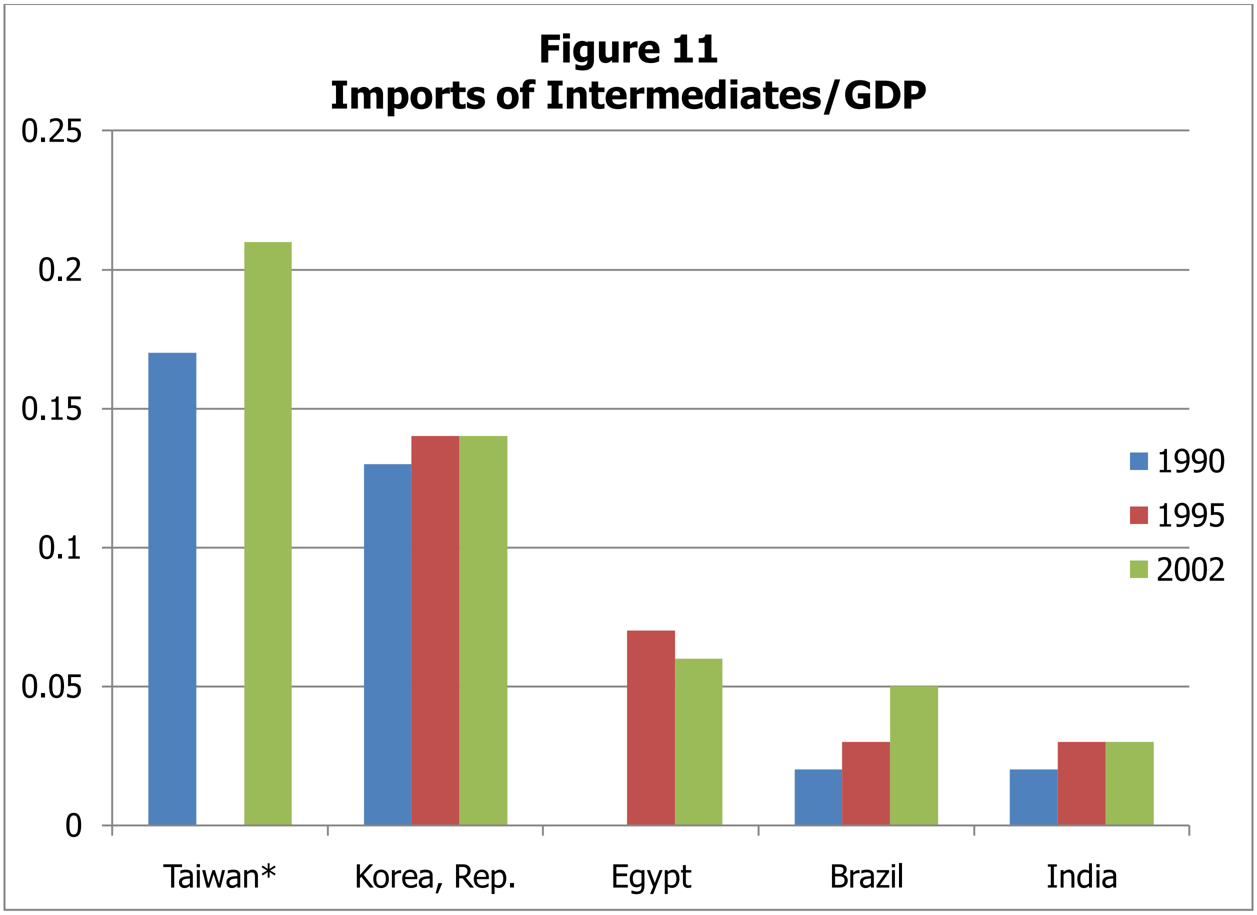


Figure 11
Imports of Intermediates/GDP
0.25
0.2
0.15
0.1
0.05
0
Taiwan*
Korea, Rep.
Egypt
Brazil
India
1990
1995
2002

Figure 12A
Licensing and Royalty Payments
(millions of dollars)

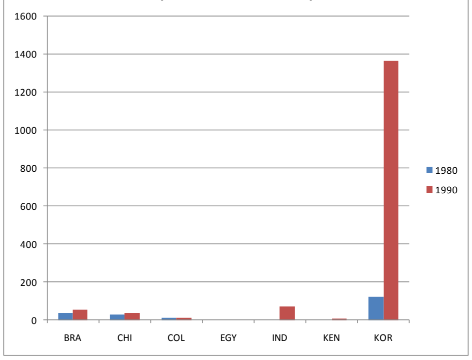
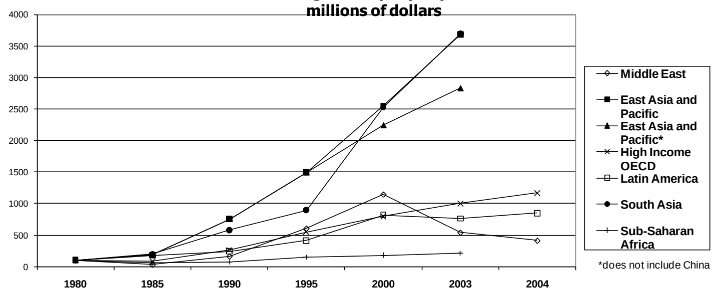


Figure 12B
Licensing and Royalty Payments
millions of dollars



Middle East: Egypt, Kuwait, Morocco, Saudi Arabia, Tunisia; **East Asia and Pacific**: China, Korea, Malaysia, Myanmar, Philippines, Thailand; **High Income OECD**: Australia, Austria, Finland, France, Germany, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, United Kingdom, United States; **Latin America**: Argentina, Bahamas, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Honduras, Jamaica, Mexico, Netherland Antilles, Nicaragua, Panama, Paraguay, Peru, Uruguay, Venezuela; **South Asia**: Bangladesh, India, Pakistan; **Sub-Saharan Africa**: Benin, Botswana, Cape Verde, Cote D'Ivoire, Ethiopia, Ghana, Kenya, Madagascar, Mali, Mauritius, Mozambique, Niger, Rwanda, Senegal, Seychelles, South Africa, Swaziland, Tanzania, Togo, Uganda.
Source: WDI

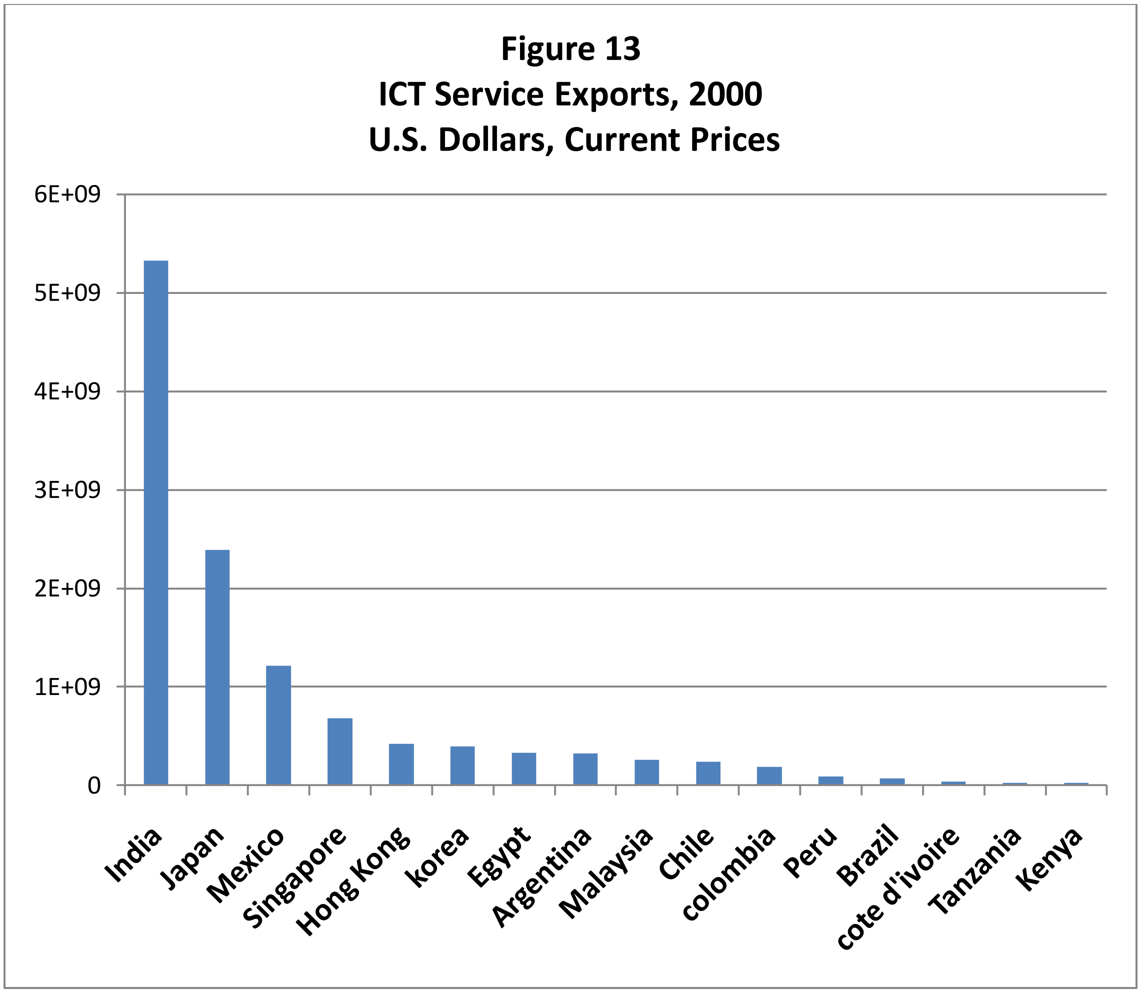


Figure 13
ICT Service Exports, 2000
U.S. Dollars, Current Prices
6E+09
5E+09
4E+09
3E+09
2E+09
1E+09
0
India
Japan
Mexico
Singapore
Hong Kong
korea
Egypt
Argentina
Malaysia
Chile
colombia
Peru
Brazil
cote d'ivoire
Tanzania
Kenya