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Technology and Long-run Economic Growth in Asia

Technological Development and Economic Growth in Indonesia and Thailand since 1950

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September 8th, 2005
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1. Introduction

Can technological progress explain differences in growth rates? Interest in technological progress has been revived in recent years by the so-called new growth theory (Fagerberg 1994). This contribution compares long-run economic growth in Indonesia and Thailand in relation to technological progress. It is argued that technological progress as shaped by official policies and the institutional framework of absorption provides an explanation why outcomes have differed so much despite apparently similar conditions under which economic growth took place. Or, more generally formulated, macroeconomic policies need to pay explicit attention to the acquisition of modern technologies in order for rapid economic growth to be sustained (Pack 1992: 300).

Our comparison between Indonesia and Thailand is based on a number of similarities and differences in initial conditions and subsequent performance. In the early 1990s, Thailand and Indonesia were both included in the World Bank's category of so-called Highly Performing Asian Economies characterized by what then appeared a sustainable path of steeply increasing levels of GDP per capita underpinned by rapid capital accumulation and a spectacular enlargement of exports (World Bank 1993: 12). The point of departure in both countries in the 1950s was also similar, in particular with regard to per capita levels of GDP and economic structure. In both countries, nearly four-fifths of the labour force found employment in agriculture whereas the share of manufacturing in GDP amounted to a mere 10 % (ILO 1996: 214-216; UN 1965: 396, 729). The endowment of natural resources was, and still is, considerably richer in Indonesia than in Thailand which obviously does not as such explain why Indonesia should lag behind.

The chief difference between the two countries lies in the speed and stability of economic growth. Factor accumulation was rapid in both countries but Thailand has apparently been capable of putting resources to use in a more efficient and productive way. There are two likely explanations for such a difference. The first one is technical efficiency, i.e. the rate of technological development optimizing output under given input constraints. The second one, institutional efficiency, refers to the development of institutions that may reduce transaction costs and facilitate economic change. These two types of efficiency are complements rather than substitutes of one another. Our aim is to gain an insight into major differences in technical and institutional efficiency between Indonesia and Thailand.

Technology is conventionally defined as 'a collection of physical processes that transform inputs into outputs and knowledge and skills that structure the activities involved in carrying out these transformations' (Kim 1997: 4). A number of factors determine the rate at which technological progress occurs: the openness of the economy as reflected by foreign trade and investment, human capital development, infrastructure and business institutions, a competitive environment and institutionalization of national research and development (R & D) efforts (Hill 2004b: 356-357). Several of these receive ample attention below, in particular the manifestations of the economy's openness, the institutional environment and national R & D policies.

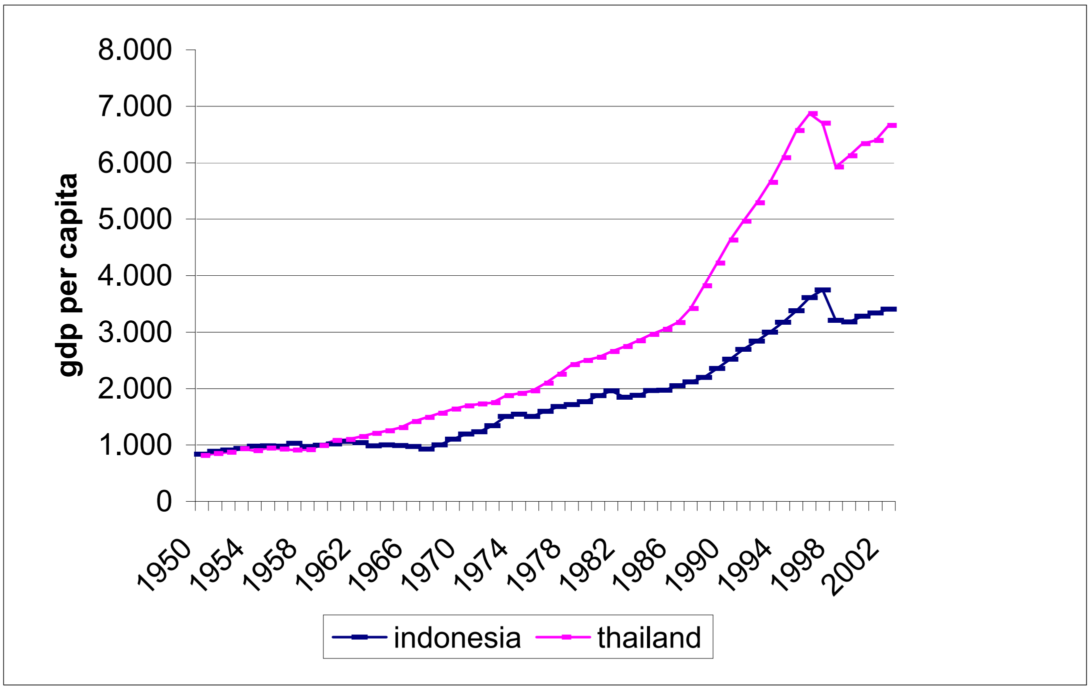
The structure of the paper is as follows. In section 2 we analyze long-run economic development in a growth accounting framework whereas in section 3 changes in economic structure are related to technological upgrading. Sections 4 and 5 are devoted to foreign imports of capital goods and FDI respectively. In section 6 we turn to the organization of domestic R & D and in section 7 institutions and national policies vis-à-vis technology are reviewed. Section 8 offers a summary and conclusions.

2. Factor accumulation and factor productivity

Long-run paths of economic development may be compared using the ratio of GDP per capita in Indonesia and Thailand respectively. In 1950, levels were very similar at a ratio of 1.03 but by 2002, the ratio had dropped to 0.51, i.e. GDP per capita in Indonesia was about one-half of that in Thailand (Maddison 2003: 184). Two phases of divergence stand out in the long-run development over the intervening half a century (Figure 1). The first period runs from 1957 to 1967 when the GDP ratio between Indonesia and Thailand dropped to 0.63. Then a period of catch-up growth on the part of Indonesia followed, until 1968, when the ratio reached 0.81. The second period of divergence runs from 1975 to 1995 when the GDP ratio fell gradually eventually reaching 0.51, i.e. the same level as in 2002.

The two periods of divergence differed fundamentally. The first one may be interpreted as the failure of Indonesia to sustain immediate post-war economic growth during the latter half of the Sukarno administration. The second period of divergence, however, was caused by a growth acceleration in Thailand rather than by slow growth in Suharto's Indonesia. On the contrary, from the mid-1980s to the onset of the Asian crisis, Indonesia achieved very high growth rates too. The rapid growth of Indonesian GDP per capita between 1985 and 1997 did not significantly reduce the ten-year time lag of Indonesia behind Thailand in terms of per capita GDP growth. The Thai level of GDP per capita in 1973 ($ 1,875 in 1990 international PPP-adjusted Geary-Khamis dollars) was reached by Indonesia in 1983. By the time the Asian crisis erupted in 1997, Indonesia had just surpassed the 1987 level in Thailand ($ 3,418).

Figure 1. GDP per capita in Thailand and Indonesia, 1950-2002, Indonesia and Thailand.



Source: Maddison 2003: 184.

Our further analysis of long-run growth paths is aided by a decomposition into two main sources of economic growth: accumulation of factors of production and total factor productivity (TFP), i.e. the efficiency with which these factors are employed. In order to execute this growth accounting we use a Cobb-Douglas production function including labour, physical capital and human capital. We assume that each of these three factors of production contributes one-third to GDP (Mankiw, Romer and Weil 1992: 432). We further assume that factors are paid according to marginal rates of return, yield constant returns and can serve as perfect substitutes for one another. The production function is then given by:

$$Y = A(L^{\alpha}K^{\beta}H^{1-\alpha-\beta}) \text{ with } \alpha = \beta = 1/3$$

where Y is GDP, A is a general measure of efficiency (including technology and institutions), L refers to labour, K to physical capital and H for human capital.

GDP growth is decomposed into the individual growth rates of the three factors of production (K, L and H) and a residual denoted as Total Factor Productivity (TFP). We calculated growth rates in Indonesia and Thailand over the entire period 1960-2000. The growth rate of the labour force is derived from the Groningen Growth and Development Centre (GGDC) Total Economy Database. Time series for the growth rate of the capital stock are derived from gross fixed capital formation data in the *World Development Indicators 2004* (World Bank 2004), for Indonesia supplemented by an extrapolation backwards from the World Bank figures using auxiliary estimates for capital formation in Indonesia during the years 1960-1978 (Keuning 1988: 16).

Since primary data on the volume of the initial physical capital stock are lacking we follow Caselli (2003: 5) in applying a formula to infer initial stock, K_0, from investment data: [1]

$$K_0 = I_0/(g+\delta)$$

where I_0 is the initial investment level in 1960, *g* the average geometric growth rate of investment in 1960-1969 (the first decennium for which figures are available) and δ

[1] This formula is based on the equilibrium outcome of the Solow model in which annual investment in an economy in steady state exactly compensates for the relative decline of fixed capital due to depreciation and (eventual) employment growth.

the average annual depreciation rate of capital stock which is assumed to equal 0.06 in both countries.[2] The growth rate of the physical capital stock is then estimated by applying a linear perpetual inventory method defined as:

$$K_t = K_{t-1} + (I_t - \delta K_{t-1})$$

where K_t is the level of physical capital stock at time *t* and I_t refers to the level of investment in the same year.

The growth of human capital stock is the most difficult to measure since only education data are readily available. This implies that effects of working experience and learning by doing accumulation are neglected. On the other hand, the level of education forms an important condition for establishing effects of learning by doing. We use average years of schooling from the Barro-Lee Database as a proxy for the growth of human capital during the years 1960-2000. The equation to measure growth in human capital stock is given as:

$$h = e^{cs}$$

where *c* is set at 0.134 representing the rate of return to one year of schooling *s*. This estimate is originally derived from calculations on the rate of return to schooling Psacharapoulos (1994). The measure of *s* refers to the average years of educational attainment of the working-age population between 25 and 64 years.

The final decomposition of GDP growth for the period 1960-2000 into three sources of factor accumulation - labour, capital and human capital - and TFP is presented in Table 1.

Table 1. Accounting for GDP growth in Indonesia and Thailand, 1960-2000.

	GDP	Labour	Physical capital	Human capital	TFP
Indonesia	4.34	0.81	2.82	0.40	0.31
Thailand	6.47	0.80	3.,36	0.30	2.02

2 This estimate of depreciation is widely used in literature. Since it is assumed to be identical in both countries the choice of level is of no consequence for the calculations (Caselli 2003: 5).

Sources: Maddison 2003: 184; GGDC, Total Economy Database 2005; World Bank 2004; Barro-Lee Database 2005.

This calculation is admittedly somewhat speculative because of its bold assumptions. Yet, it does demonstrate clearly that the growth gap between Indonesia and Thailand during the years 1960-2000 cannot be attributed to differences in the accumulation of production factors alone. The accumulation of physical capital in Thailand occurred at a faster pace (0.54%) than in Indonesia. Nevertheless, the accumulation of labour and human capital took place at a more or less similar rate. The crucial difference between the two countries lies in TFP where the Thai level exceeded the Indonesian level by an average of 1.71 percentage points.

Interpreting TFP invariably poses a problem. In a classical interpretation TFP growth reveals growth in labour productivity due to technological progress, but in practice, a whole set of social capabilities may, in combination, impact on the level of TFP growth (Abramovitz 1986). Therefore, it is hard to pin down the exact contribution of technological progress to TFP.

Technological development originates, amongst others, from higher average levels of schooling. Education creates important conditions for developing skills needed to adopt, adapt and apply new technology (Goldin and Katz 1996: 1). Booth has argued that the relative underdevelopment of Indonesia's education system was a major cause of the country's poor economic performance in comparison to other Southeast Asian countries such as Malaysia and indeed Thailand (Booth 1999). Yet, a higher level of education is also likely to result in a higher level of institutional efficiency that in turn may have brought about Thailand's lead in human capital development. Literacy rates and secondary schooling levels, measured as a percentage of the working-age population between 15 and 64 years, are almost twice as high in Thailand as in Indonesia (Barro-Lee Database). The catch-up achieved by Indonesia during the second half of the twentieth century was insufficient to match Thai levels of education.

The ultimate cause of the growth divergence between Indonesia and Thailand may as well reside in their different education policies, whereas the technological differences are merely a result, or a characteristic, of the growth divergence, rather than the main cause. This needs to be borne in mind in the following analysis of main indicators of technological development.

3. Structural change and technology

The structure of the economy changed profoundly in both Thailand and Indonesia during the second half of the twentieth century. In Thailand, the share of manufacturing in total GDP rose from 14 % in 1960 to 40 % in 2000 whereas the share of the primary sector fell from 37 % to 10 %, a virtual reversal of positions held by these two sectors that together accounted for more than one-half of the country's GDP (Brimble 2003: 340; details in NESDB 1987-2000). A similar turnabout of the contributions by the primary and secondary sectors towards GDP occurred in Indonesia where the share of agriculture fell from 53 % in 1966 to 20 % in 1992 while manufacturing rose from 10 % to 35 % during the same period (Hill 1996: 18-19). Both Indonesia and Thailand matured into becoming industrializing countries during a remarkably short time span.

Within manufacturing, a dramatic shift took place away from labour-intensive lines of production using little advanced technology towards capital-intensive branches necessitating a higher level of technological sophistication. In the mid-1950s, more than one-half of total employment in manufacturing in both Thailand and Indonesia was concentrated in two highly labour-intensive branches of industry alone, food processing and textiles (UN 1965: 396, 729).

It is instructive to compare changes in the distribution of value-added and employment in manufacturing in Thailand and Indonesia in longer time perspective ranging from around 1960 to 1996, i.e. from just before the thrust towards industrialization until the eve of the Asian crisis (Table 2). Three traditionally highly labour-intensive branches of manufacturing – food (with beverages and tobacco), textiles, clothing and footwear – saw their share in total manufacturing value-added drop from 46 % to 34 % in Indonesia and from 62 % to 31 % in Thailand. Meanwhile, the most capital- and technology-intensive industries – metals, machinery and transport equipment – gained from 11 % to 25 % in Indonesia and from 5 % to 35 % in Thailand. These figures do not only underscore that a major change did indeed take place within manufacturing between about 1960 and 1996 but also that the change was bigger for Thailand than for Indonesia.

We next focus on the final decade of structural change within manufacturing, i.e. the years from the mid-1980s up to the late 1990s. In Thailand, per capita value-added manufacturing using medium- or high-level technology increased from $ 167 in 1985 to $ 585 in 1998 corresponding to respectively 18 % and 40 % of total manufacturing value-added. In Indonesia, there was similarly an increase from $ 86 (25 %) in 1985 to $ 115 (40 %) in 1998 (UNIDO 2002: 162, 164).[3] The relative share of medium- or high-level technology in total manufacturing value-added is strikingly high in Indonesia but, significantly, average value-added in the late 1990s was still below the level that had been achieved by Thailand in the 1980s. This again testifies to a time lag of about one decade between Thailand and Indonesia.

Table 2. Value-added and employment in manufacturing in Indonesia in 1958 and 1996 and in Thailand in 1963 and 1996

	Indonesia 1958			Thailand 1963		
	% distribution value added	% distribution Employment	relative labour productivity	% distribution value added	% distribution Employment	relative labour productivity
Food, beverages and tobacco	38.0	33.8	1.12	56.6	39.6	1.43
Textiles	6.9	16.3	0.42	5.5	16.2	0..34
Clothing and footwear	0.8	9.0	0.09	0.2	0.6	0.31
Wood and furniture	1.7	3.9	0.44	6.8	13.6	0.50
Paper and paper products	1.4	0.8	1.75	0.3	1.1	0.26
Printing and publishing	6.0	5.4	1.11	2.4	3.3	0.72
Leather and leather products	2.7	2.6	1.04	0.3	0.4	0.77
Rubber products	14.9	5.0	2.98	4.5	2.0	2.27
Chemicals and chemical products	12.0	6.7	1.79	5.6	5.1	1.10
Non-metallic mineral products	3.7	4.0	0.93	9.1	7.4	1.23
Basic metals	..	..		***3.4***	***3.9***	***0.88***
Metal products	***10.9****	***10.3****	***1.06***	***4.6***	***5.1***	***0.91***
Other manufacturing	1.0	2.2	0.45	0.7	1.7	0.43
Total	*100*	*100*	*1.00*	*100*	*100*	*1.00*
	Indonesia 1996			**Thailand 1996**		
Food, beverages and tobacco	16.4	19.2	0.86	23.0	17.4	1.33
Textiles	11.2	15.0	0.74	5.0	9.4	0.53
Clothing and footwear	6.8	16.6	0.41	3.5	9.9	0.36
Wood and furniture	6.9	13.4	0.52	1.6	2.4	0.66
Paper and paper products	3.6	2.2	1.61	3.5	1.8	1.92
Printing and publishing	1.9	1.7	1.15	3.2	1.9	1.67
Leather and leather products	0.3	0.6	0.54	0.7	1.1	0.67
Rubber products	1.9	3.0	0.62	3.9	3.3	1.17

[3] According to conventional OECD definitions, medium-technology production refers to electrical machinery, transport equipment and chemicals whereas hi-tech production embraces aircraft, pharmaceuticals, accounting and computing machinery, radio, television and communications equipment as well as medical and precision instruments (OECD 1987).

Chemicals and chemical products	9.6	4.4	2.16	6.3	3.9	1.63
Non-metallic mineral products	4.3	8.5	0.50	7.0	6.4	1.09
Basic metals	11.3	1.2	9.42	1.9	1.8	1.06
Metal products	4.3	3.9	1.11	3.8	5.4	0.70
Non-electrical machinery	1.7	1.1	1.54	3.2	4.7	0.68
Electrical machinery	7.7	4.0	1.95	12,.	11.3	1.11
Transport equipment	11.0	3.2	3.47	15.7	5.4	2.92
Professional and scientific equipment	0.3	0.4	0.84	1.3	1.3	0.95
Other manufacturing	0.8	1.7	0.46	3.8	12.5	0.30
Total	*100*	*100*	*1.00*	*100*	*100*	*1.00*

Sources: UN 1970-1972: vol. 1; UN 2002.

The rise of manufacturing in recent years in both countries has obviously been conditioned by a strong orientation towards exports. In either country foreign exports correspond to more than 50 % of GDP, which is relatively high by international standards, albeit far lower than in neighbouring Malaysia, let alone Singapore (Hill 2004b: 360-361). For our purposes, however, the important matter is the composition of exports by type of commodity and level of technological sophistication. A crude measure is the proportion of total exports occupied by capital goods. In Thailand, the share of capital goods in aggregate (non-oil) exports began to climb above a marginal or trivial level during the late 1970s. The percentage quadrupled between 1978 and 1987 and rose more than threefold during the next decade (Table 3). In Indonesia, however, a decisive increase in the share of capital goods only occurred in the early 1990s.[4] Again, we encounter a time lag of about ten years, or slightly more, between the two countries.

Table 3. Share of capital goods in non-oil exports from Indonesia and Thailand, 1972-1996.

	Indonesia	Thailand
1972	1.6	0.7
1975	1.8	1.7
1978	1.7	3.3
1981	2.0	5.2
1984	2.4	7.3

[4] Oil exports were excluded in order to enhance comparability. The time lag between Thailand and Indonesia would obviously be even larger if oil exports were included.

1987	0.5	11.9
1990	2.0	22.0
1993	7.1	29.7
1996	11.7	37.8

Source: UN, *International Trade Statistics Yearbook* 1972-1996.

It is instructive to take a closer look at the technology content embodied in manufactured production for foreign markets as it reveals the degree to which advanced technologies are actually mastered. After 1980, the combined share of resource-based and labour-intensive exports in total manufactured exports from Thailand fell consistently, from 69 % in 1980 to 59 % in 1990 and further to 47 % by 2000. Meanwhile science-based exports gained from 1 % to 26 % whereas scale-intensive or differentiated exports remained by and large as important as before (Brimble 2003: 341).[5] In Indonesia, by contrast, resource-based and labour-intensive exports in 1992 still accounted for as much as 88 % of total manufactured exports (Hill 1996: 163).

The technological lead enjoyed by Thailand above Indonesia is brought out by a slightly different kind of differentiation isolating medium- or high-technology products in the range of manufacturing exports. The share of these goods in total manufacturing exports amounted to 23 % in Indonesia in 1996 which was scarcely higher than the corresponding share for Thailand in 1985, 20 %, but a far cry from the 50 % share in 1996 (Wong and Ng 2001: 15). Also by using this yardstick, we may thus observe a time lag of about ten years between the two countries.

A rising technological content in export production inevitably has repercussions for import demand as well. This applies in particular to high-tech products. Differences in terms of technological upgrading of the manufacturing sector between Indonesia and Thailand may be highlighted by focusing on six categories of high-tech products. Traded values and productivity levels are given for 1995, i.e. shortly before the onset of the Asian crisis (Table 4). In all six categories of high-tech products, Thailand both imported and exported more than Indonesia. Thailand enjoyed, and still enjoys, a

5 Resource-based exports: food, wood, rubber and non-metallic minerals; labour-intensive exports: garments and leather; science-based exports: pharmaceuticals, plastics and chemicals; scale-intensive exports: textiles, paper, chemicals, steel and transport equipment; differentiated exports: metals and machinery.

comparative advantage above Indonesia, especially with regard to office and electrical machinery. This renders support to the hypothesis about a substantial difference in TFP between the two countries.

Table 4. Trade and productivity in high-tech manufacturing in Indonesia and Thailand in 1995.

Aggregate values ($ thous.) and value per person employed ($).

	Indonesia		Thailand	
	Imports	Exports	Imports	Exports
Traded high-tech manufacturing goods				
Pharmaceutical products	249,650	0	473,203	126,297
Metal-working machinery	596,238	0	1150,729	0
Office, computing and accounting machinery	241,110	501,433	3004,503	5720.005
Electrical machinery, apparatus, appliances and supplies	1965,631	808,485	9581,183	6395,159
Professional, scientific, measuring and controlling equipment	441,386	0	948,223	311,461
Photographic and optical goods, watches and clocks	263,653	200,042	618,003	687,030
Estimated employment (thous.)	80,110		32,575	
Value per person employed				
Pharmaceutical products	3.12		14.53	3.88
Metal-working machinery	7.44		35.33	
Office, computing and accounting machinery	3.01	6.26	92.23	175.59
Electrical machinery, apparatus, appliances and supplies	24.54	10.09	294.13	196.32
Professional, scientific, measuring and controlling equipment	5,51		29.11	9.56
Photographic and optical goods, watches and clocks	3.29	2.50	18.97	21.09

Sources: GGDC Total Economy Database; UN, *International Trade Statistics Yearbook 1995*.

The economies of Thailand and Indonesia have both changed almost beyond recognition since the 1950s and technological progress has clearly played an important part in either case. The time is ripe to turn to ways in which access has been gained to modern technologies.

4. Foreign imports of capital goods

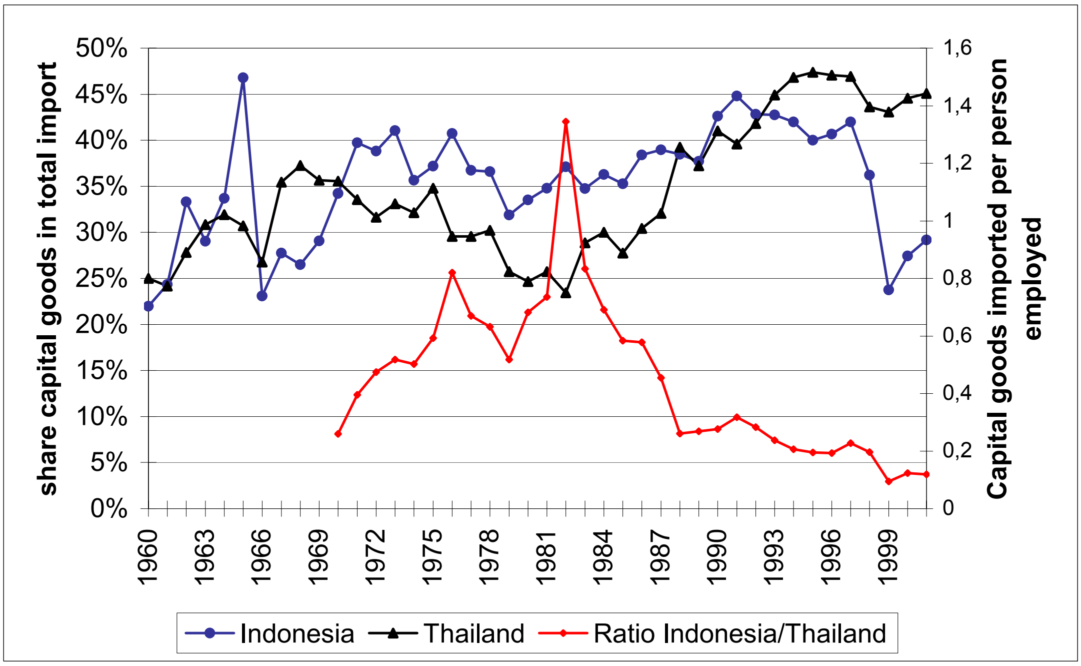
Access to new technology is realized through a variety of channels such as reverse engineering, licensing, Original Equipment Manufacturing and labour mobility. All played a prominent part in the technological upgrading of production in East Asian NIEs such as South Korea and Taiwan since the Second World War. Another potentially powerful vehicle is FDI (section 5 below). The most popular channel of technology transfer, however, is imports of capital goods embodying technology that is either too new or too complex to be produced domestically (Pack 1992; Nabeshima 2004). A global survey of country-specific statistics reveals that one-fourth to one-half of gross domestic capital formation in developing countries took place via imports of capital goods from developed and advanced developing countries during the second half of the twentieth century (IMF 1960-2000). Import statistics may therefore serve as an important source of information about the composition of investment in physical capital.

According to neo-classical growth theory, catch-up growth by less developed countries occurs as a result of technological diffusion from industrial to developing countries (Gerschenkron 1962; Abramovitz 1986). In this ideal type of economic development, two distinct stages may be identified with respect to foreign trade and capital goods. The share of capital goods in total imports first increases as the country embarks on catch-up growth while during the second stage capital goods form an increasing proportion of total exports, as we saw above in the cases of both Thailand and Indonesia.

In the 1950s, the share of capital goods in total imports was 15-25 % in both Indonesia and Thailand. By the late 1990s, this proportion had increased to nearly 45 % in Indonesia and 48 % in Thailand (Figure 2). When expressed per person employed, the Indonesian share of capital goods in total imports turns out considerably lower than that of Thailand with the sole exception of the year 1982. The 1970s and early 1980s show a remarkable catch-up by Indonesia whereas Thailand rapidly has moved ahead since the mid-1980s.

Figure 2. Share of capital goods in total imports entering Indonesia and Thailand, 1960-2001.

Ratio of capital goods imports per person employed (Thailand = 1.0)

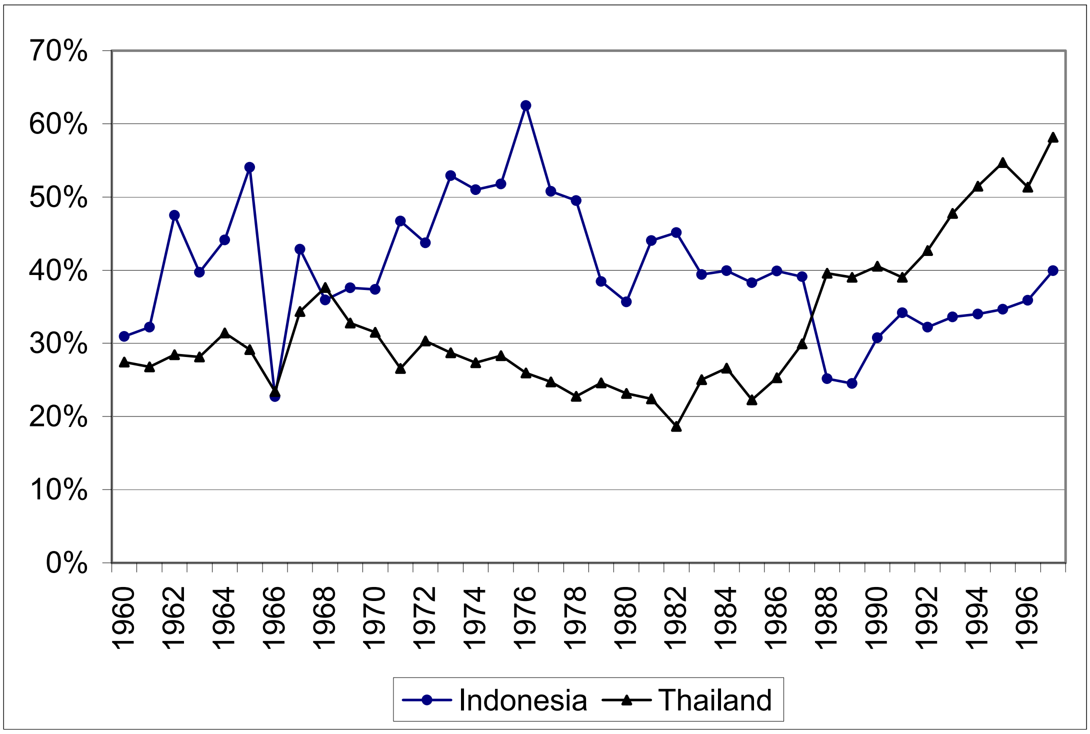


Note: Capital goods refer to all products classified as category 7 in the Standard International Trade Classification (SITC, 2nd revision), i.e. machinery and transport equipment.

Source: UN 1960-2001.

The share of capital goods imports in gross fixed capital formation displays a similar pattern (Figure 3). From 1985 onwards, this percentage increased very fast in Thailand but in Indonesia it declined and only slowly recovered during the 1990s. This testifies to one similarity and one difference between Indonesia and Thailand with regard to the contribution of capital goods imports in technological upgrading, i.e. overall a substantial increase but at the same time a reinforced lead by Thailand above Indonesia due to an acceleration in recent years.

Figure 3. Percentage share of capital goods imports in gross fixed capital formation in Thailand and Indonesia, 1960-1997.



Sources: UN 1960-2001; World Bank 2004; Keuning 1988:16.

A common feature of change in the composition of imports refers to the declining share of transport equipment as opposed to machinery. During the 1960s, transport equipment accounted for 35-40 % of all imports in both countries but by 1997 this proportion had dropped to 19 % in Indonesia and 15 % in Thailand. Meanwhile, imports of machinery grew in both absolute and relative terms. Expressed as a percentage of GDP, imports of capital goods doubled between the 1970s and 1990s in Thailand and rose by more than 50 % in Indonesia over the same period (UN 1960-2001).

But purchasing the most modern machinery from abroad is not enough. A high positive correlation can be established between per capita income growth rates in developing countries on the one hand and machinery imports from developed and advanced developing countries on the other if the latter variable is combined with a measure of investment in human capital stock (Mayer 2001: 40).[6] An effective technology transfer through capital goods imports thus presupposes an enhanced

[6] Mayer's multiple regression analysis covered 46 developing countries, including Indonesia and Thailand, during the years 1970-1997.

absorptive capacity which in turn is facilitated by investment in human capital. This conclusion applies to both Indonesia and Thailand (see further section 7 below).

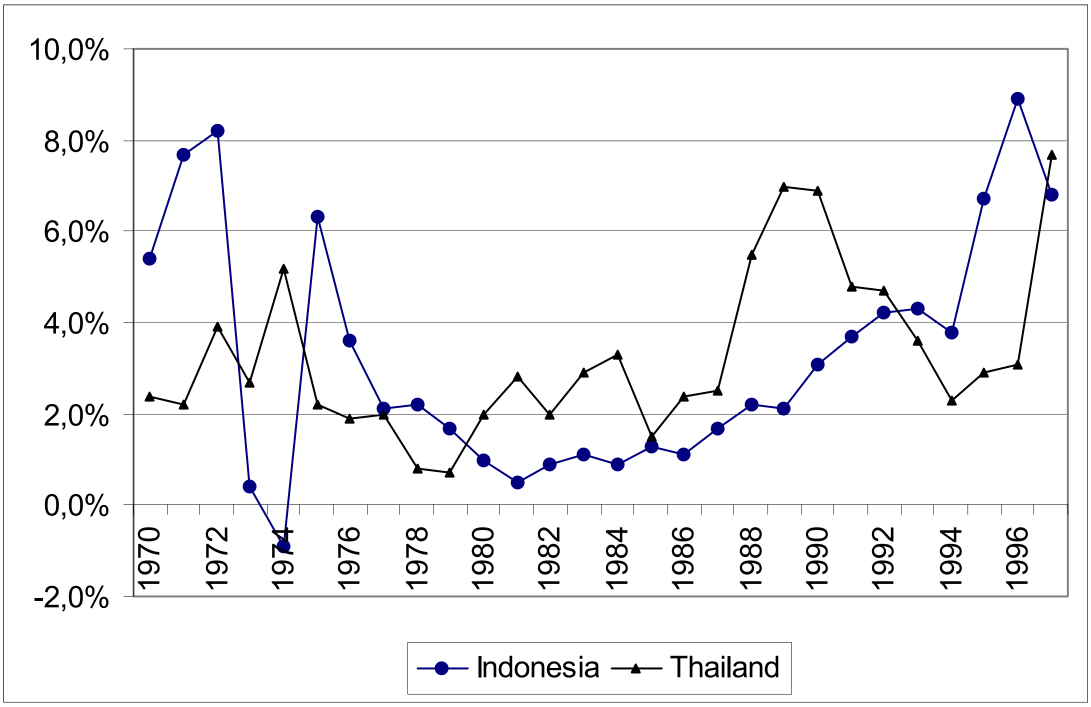
5. Foreign direct investment

Different from imports of capital goods, FDI is not only a potential source of technological spillovers but it also enhances organizational and institutional capabilities thus stimulating technological development in the host economy in general. Levels of incoming FDI reflect the attractiveness of a country's investment climate as determined by aggregate consumer demand, macro-economic and political stability and comparative advantages in production such as low relative wages, a lack of rigid environmental or labour regulations and a good physical infrastructure. However, whether the host country actually benefits from positive spillover effects is not at all certain. The extent of positive FDI spillovers depends on the time horizon and commitments made by the investor as well as the institutional environment in the host country. FDI alone can never form a sufficient condition for sustained technological development (Blomström and Kokko 2001; Thee 2001).

FDI obviously plays an important role in the economic development of both Indonesia and Thailand, although its contribution towards capital formation is far smaller than in Malaysia, let alone Singapore. In Thailand, net FDI inflows corresponded to on average of 3.3 % over the entire period 1970-1997, about 25 % of the level in Malaysia or 15 % of the Singapore level. FDI approvals in Indonesia were of a similar order of magnitude but that percentage needs to be adjusted downwards to account for a relatively low rate of realization (World Bank 2004).[7] FDI in both countries displayed a high volatility over time as expressed by a considerable standard deviation at almost 80 % of the long-run annual average (Figure 4). Volatility of FDI in both Indonesia and Thailand became especially pronounced during the financial crisis in the late 1990s (Hill 2002: 21-23).

[7] Published FDI statistics for Indonesia generally refer to approvals rather than implemented investment. Comparison of the official aggregate of approvals (outside oil and banking) during the period 1967-1996 as given by the Indonesian Capital Investment Coordinating Board BKPM (*Badan Koordinasi Penanaman Moda*l) with unofficial estimates of actual investment suggests a realization rate that may be as low as one-third (Ramstetter 2000: 42; cp. UN 1992: 141).

Figure 4. Fluctuations in FDI inflows expressed as a percentage share of gross fixed capital formation in Indonesia and Thailand, 1970-1997.



Note: FDI inflows probably reflect approvals in Indonesia and implemented investment in Thailand but this is not stated unambiguously in the source.
Source: World Bank, World Development Indicators 2004.

The technology content of inward FDI may be inferred from the sectoral distribution of FDI. In Thailand, the share of the high-tech branches of manufacturing, electrical and electronic products and machinery, in total FDI rose from 10 % in the 1970s to 15 % in the 1980s and further to 17 % in the 1990s. This corresponded to an increase in the proportion out of total manufacturing FDI from 27 % in the 1970s to 50 % in the 1990s and it appears that the high-tech proportion of FDI continued to rise during the recovery in the early years of the twenty-first century (Bank of Thailand 2002: Table 63). The high-tech proportion is known to be far lower in Indonesia and was reported at a mere 13 % of FDI in manufacturing over the years 1982-1991, the equivalent of no more than 2-3 % of all incoming FDI (STAID 1993: Table 6.8).

Stock data on FDI prepared by the United Nations permit a further elaboration on the technology content of FDI entering Indonesia and Thailand, regrettably, however, not for a later date than the late 1980s. The composition of FDI by industry immediately reconfirms that FDI in Thailand is far more directed towards technology- and knowledge-intensive production than in Indonesia (Table 5). Although, it should be noted that the contrast between the two countries is overdrawn by the very large share of oil in accumulated FDI stock in Indonesia, this also demonstrates the one-sidedness of Indoneisan FDI. During the 1980s, FDI in Thai manufacturing saw a shift away from low-technology production, notably textiles, towards hightech-intensive manufacturing such as mechanical and electrical equipment. In Indonesia the share of the Oil industry increased with another 13,5%.

Table 5. Industrial distribution of accumulated FDI stock in Indonesia and Thailand in 1980 and 1988/89.

Percentage share	Indonesia		Thailand	
	1980	1988	1980	1989
Primary sector	*70.4*	*80.5*	*13.6*	*9.2*
Agriculture	5.1	2.1	1.1	1.3
Mining and quarrying	4.6	4.2	2.0	0.9
Petroleum	60.7	74.2	10.5	7.0
Secondary sector	*25.4*	*16.9*	*31.7*	*42.8*
Food, beverages and tobacco	1.7	1.5	3.3	3.6
Textiles, leather and clothing	8.7	3.5	10.1	4.1
Chemicals	4.0	3.7	4.3	5.7
Metals	7.1	5.9	1.5	4.5
Mechanical and electrical equipment			10.0	16.9
Other manufacturing	3.8	2.3	2.6	7.9
Tertiary sector	*4.2*	*2.5*	*54.7*	*48.0*
Construction	0.5	0.4	13.2	11.6
Distributive trade	1.0	1.0	21.1	16.6
Transport, storage and communication	0.5	0.2	5.3	2.6
Finance and insurance			10.7	6.7
Other services	2.2	0.9	4.4	10.6
Total	*100*	*100*	*100*	*100*

Source: UN 1992: 147, 320.

The higher technological content of FDI entering Thailand testifies to a greater capacity of absorption of new technology which in turn is influenced, amongst others, by official R & D-policies (cp. Hill 2004a). On the other hand, the heavily biased distribution of Indonesian FDI at least suggests the existence of crowding out effects, hampering potential technology spill-overs in other manufacturing industries.

6. Research and Development

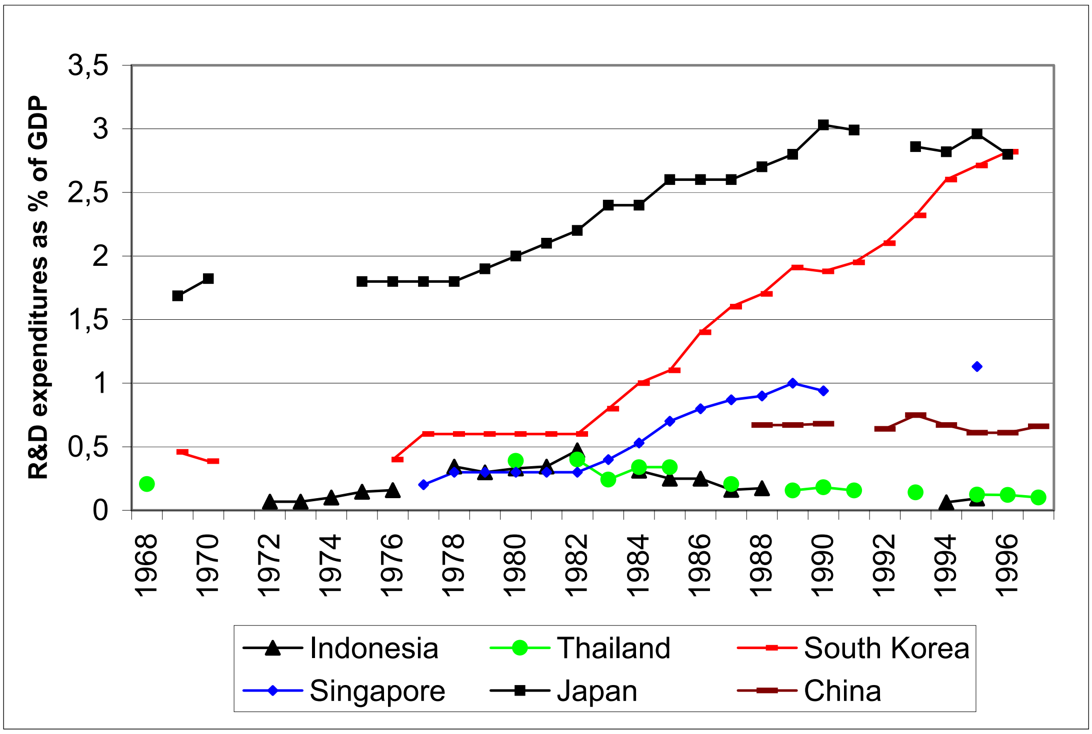
R&D is conventionally defined as `any creative systematic activity undertaken to increase the stock of knowledge […] and the use of this knowledge to devise new applications' (UNESCO 1998: 5-1). This is a broad definition that includes fundamental and applied research in all areas of science and production. In developing economies the focus is usually on shifting the domestic technology frontier in order to facilitate implementation. Strategies with respect to investment in domestic R&D vary considerably, from heavily funded government programs in South Korea and Taiwan to limited efforts as in Singapore and, indeed, Thailand (Lall and Urata 2003).

Governments play a key role in encouraging and facilitating R&D. Because of high risks and considerable investment commitments, operations in such endeavours are likely to remain suboptimal unless the government is actively involved. There is always the problem of the free rider. In addition, absence of market discipline may create incentives for rent-seeking and it is far from certain that a country can dispose over the required physical and human resources. Worse still is the risk that investment in R&D serves a political rather than an economic priority. The most flagrant example is the ill-fated but very costly attempt by Indonesia in the mid-1990s to set up an aircraft industry of its own, spearheaded by B.J. Habibie, then Minister for Research and Technology, the later President. Attempts at such a short-cut ignores that technological progress is generally a slow and gradual process. In addition, incentives to corruption easily germinate in weak institutional soils.

The success of government-directed R&D policies is constrained by various non-technological conditions and it becomes difficult to directly link R&D activities to technological progress. A given R&D input does not guarantee a certain output. Figures on R&D expenditures and numbers of persons employed in R&D activities merely inform us about the scope of efforts and financial commitments but do not offer an insight into the effectiveness of R&D efforts.

The most straightforward indicator of R&D activities is the percentage share of R&D expenditure in total GDP. It is useful to review such statistics in a comparative regional context (Figure 5). R&D expenditures in both Indonesia and Thailand have remained relatively low compared to Singapore from the mid-1980s and China in the early 1990s whereas Japan and South Korea both moved towards the 3 % level considered appropriate for OECD economies. The R&D proportion of GDP in Thailand actually fell from a peak at 0.4 % in the early 1980s to only 0.1 % in 1996, which must be ascribed to the very rapid economic growth during the decade and a half immediately preceding the Asian crisis. There was a similar development in Indonesia with R&D declining from 0.47 % of GDP in the early 1980s to 0.2 % in 1996, again conditioned by rapid economic growth without concomitant investment in technology (Wong and Ng 2001: 17).

Figure 5. R&D expenditures as a percentage share of total GDP in selected Asian countries, 1968-1998.



Sources: NSTDA 1999; STAID 1993; UNESCO 1972, 1980, 1998

Data for the year 2000 suggest a hierarchy in the region with Singapore at the top with 1.13 % R&D of GDP, Malaysia in the middle (0.24 %) and Thailand in the lower range with only 0.13 %. In money terms, this meant that Thailand spent less than $ 6 per person on R&D each year which, however, is still appreciably more than $ 1 as was the case in Indonesia in 1999 (Brimble 2003: 360-363). Significantly, Thailand at that time paid more than twice as much and Indonesia five times as much in royalties and licences accruing to proprietors of technology abroad (UNIDO 2002: 169-170).

Developed economies in the region have witnessed a shift away from government-sponsored R&D towards privately funded R&D. In Japan, for instance, the share of government-funded R&D fell from 29 % in 1976 to 18 % in 1991 and in South Korea the decline was even steeper, from 47 % in 1977 to 16 % in 1994 (UNESCO 1972, 1980, 1998). Such a restructuring of the R&D-effort has not yet taken place in Thailand or Indonesia. The government share in Thailand was reported at 85 % in 1991 and as much as 89 % in 1997 whereas in Indonesia it amounted to 80 % in 1991 (NSTDA 1999; STAID 1993). In Thailand the main agents for dissemination of new technology are the Ministry of Science, Technology and Environment, founded in 1979, and the National Science and Technology Development Agency, established in its current form in 1991, whereas in Indonesia the Ministry of Research and Technology gained prominence after Habibie became its head in 1978.

Strikingly little is spent by private enterprises on R&D in Thailand. In the late 1990s, for instance, less than one establishment in ten possessed R&D facilities of its own in such key industries as footwear, metals, food, paper, non-metallic minerals, textiles, wood and plastics. The highest frequency of R&D facilities was found in the pharmaceuticals industry, one-third of all firms (Okamoto and Sjöholm 2003: 382, 391). In this respect it made little difference whether a firm was foreign-owned or controlled by domestic capital interests. The highest R&D expenditure, expressed as a percentage of total sales, was even reported for fully domestically owned firms, still only 2.1 % (Tangkitvanich, Nikomborisak and Kraiviksh 2004: 269). By implication, it means that little can be expected in terms of new R&D facilities from foreign direct investment. This underscores the great need for adjoining government efforts, especially in sustaining human capital formation, as has been shown for instance in the case of the electronics industry of Malaysia (Rasiah 2003: 329-330).

Supplementary evidence reinforces the general impression that R&D efforts in Indonesia and Thailand are severely lagging behind within the region. Recent years have seen an increase in numbers of scientists, engineers and technicians but percentages of personnel actively involved in R&D in total employment have remained far lower than in for instance South Korea and Singapore (Table 6).[8] Numbers of trademark applications increased somewhat in the 1990s but the share of residents was no higher than about 60 % in both Indonesia and Thailand (Shahid a.o. 2003: 174).

Table 6. Share of R&D personnel in total employment in selected Asian countries, 1970-1995.

		% R&D engaged		% R&D engaged		% R&D engaged
Indonesia	1982	0.049	1988	0.073		
Thailand	1987	0.031	1991	0.031	1995	0.039
Philippines	1980	0.067	1984	0.052	1992	0.065
South Korea	1970	0.134	1985	0.491	1994	0.959
Singapore	1978	0.174	1987	0.464	1995	0.558

Sources: NSTDA 1999; UNESCO 1972-1999.

Technological upgrading has clearly been an integral part of the economic restructuring in Thailand and Indonesia over several consecutive decades but it is doubtful whether direct efforts by the governments has played a decisive role in this. The institutional context in which new technologies find application is likely to have been more important.

7. Institutions and technology policy

The preceding analysis established a technological advantage of Thailand above Indonesia, but how can we explain this? One possible interpretation of ‘low’ progress is ‘slow’ progress. Since the level of per capita income lags behind in Indonesia by approximately ten years, it can be argued that it is just a matter of time before Indonesia will reach a comparative stage of technological development as Thailand at

[8] These numbers must be interpreted with caution since they also include auxiliary personnel.

present. The slower growth of per capita income would then itself be the result of a lower level of technological competence. Such a line of arguing seeks the explanation in general rather than country-specific characteristics of technological progress (cp. Lall and Teubal 1998).

The ‘time-lag’ hypothesis presupposes that Indonesia and Thailand move along a common or universal path of technological development, but find themselves at different stages along that path. There is surely some truth in this interpretation but country-specific differences must be considered as well. After all, the main reason for Indonesia’s initial falling behind in the 1960s was in the political arena rather than in a weak economic structure.

An assessment of country-specific characteristics goes beyond crude indicators of technological development such as levels of capital goods imports and R & D expenditure which, incidentally, as such do not provide an unambiguous explanation for Thailand’s edge above Indonesia. The level of expenditure on R & D in particular has so far only played a marginal role in both countries (section 6 above). Output indicators reveal a more distinctive pattern of comparative technological development in the two countries. The composition of technology-intensive manufacturing exports shows that Thailand has adopted and mastered the technology necessary to obtain a competitive advantage in international markets for products including electrical and electronic goods and office machinery (section 3 above). Apparently, Thai entrepreneurs and investors have been more effective in turning opportunities for technological progress into output of technology-intensive manufactured goods.

Linking input and output indicators shows that Thailand was better able than Indonesia to differentiate its technology-enhancing resources. The distribution of inward stock of FDI in Indonesia remains heavily dominated by the capital- and resource-intensive oil sector whereas in Thailand inward FDI is spread more evenly over several branches of manufacturing and service (section 5 above). This is also reflected in a larger differentiation of technology-intensive manufacturing exports (Table 4 above). These observations suggest that Thailand was more successful in diffusing new technology.

The Thai economy gained more opportunities to turn comparative advantage based on low labour costs into a competitive advantage. Broad diffusion will eventually lead to export differentiation. The question as to what explains the current technology gap between Thailand and Indonesia therefore needs to be reformulated as follows: Which country-specific characteristics facilitate the diffusion of technology? This calls for a more detailed analysis of the institutional and policy context in both countries (cp. Hill 2001).

A comparison of recent Thai and Indonesian economic and political history brings out a striking paradox. At first sight, the post-war political history of Thailand appears to have been more turbulent than was the case in Indonesia. Political instability during the Sukarno period (1945-1966) did cause serious setbacks in the economic development of Indonesia but 32-year long Suharto rule brought unprecedented political stability, at any rate on surface. The Suharto administration was strongly focused on economic development and it is generally accepted that relative macroeconomic stability forms an important explanation for the rapid economic growth of Indonesia during these years (Dick a.o. 2002: 198-201). In Thailand, however, political crises seemed endemic with political parties, the military and bureaucrats continuously competing for political control. In such a context one would expect major shifts in economic policy and a highly unstable macroeconomic climate. Conditions for rapid technology diffusion would therefore seem to have been more favourable in Indonesia. In the event, however, technology diffusion was far slower in Indonesia.

This paradox may be resolved by a separation between politics and economics. The Thai bureaucracy enjoyed a high degree of independence. It was inspired by the British system of a permanent and professional civil service loyal to the monarchy rather than to the cabinet (Warr and Nidhipabha 1996: 18-19). Under such conditions, stable financial institutions and public investment in infrastructure and education were effective. A shared commitment to sound financial policies typifies the consensus on economic policy in Thailand. The quality of financial institutions is a major precondition for a favourable investment climate reducing risks for both domestic and foreign investors while also improving access to capital markets for small-scale entrepreneurs. In Indonesia, on the other hand, the bureaucracy and the financial institutions have been proverbially weak and ineffective with corruption forming a huge and persistent problem (Dick a.o. 2002: 213-215)

In the aftermath of the Asian crisis it became clear how fragile FDI commitments were in Indonesia whereas in Thailand FDI started to catch up already in 1999 (Thee 2005; Athukorala 2003: 202-203). The investment climate in Indonesia was impaired by rising uncertainty about the country's macroeconomic stability and the legal protection of property rights.

From the perspective of technology policy, it can be argued that Thai policies were more geared towards adoption, adaptation and diffusion of technology rather than the creation of new technology whereas Indonesian investment in mega-projects was too often driven by the desire to invent rather than implement technology. Indeed, the economic spin-off of prestigious projects in for instance the Indonesian aircraft industry is likely to be have been minimal. This example does, however, touch upon a more fundamental characteristic of the economic structure in Indonesian economy, i.e. the abundance of natural resources. Ample opportunities of rent creation provided by natural resources induce the government to allocate technology resources to these profitable industries which in turn may result in serious crowding-out effects. Since the Indonesian government largely controls R & D expenditures, licensing agreements and FDI policies, the allocation of resources is likely to be driven by rent-seeking rather strategies than market discipline. Windfall gains are attractive from the perspective of rent-seeking and investors, including foreign investors.

This line of argumentation may be supported by another explanatory variable, i.e. the lag in levels of educational achievement. Since the adoption and adaptation of new technology is closely related to human capabilities, the advantage of the Thai is partly driven by their better developed system of public education. Thee (2005) points at the limited absorptive capacity of Indonesian enterprises due to a lack of skills, know-how and training facilities. The key role of education in bridging the technology gap lies in improving both access to information about new technology and abilities to digest such information, i.e. the development of learning skills (Rosenzweig 1995). Its contribution is difficult to measure but can scarcely be overestimated.

Expenditure on education, expressed as a percentage of GDP, is significantly higher in Thailand than in Indonesia, amounting to 5.0 % against 3.6 % in 1998. It should be added that the proportion of private expenditure in total expenditure differs significantly too, 60 % in Indonesia against 6 % in Thailand, which reflects a very different commitment to education in public policy (Shahid a.o. 2003: 185). Average numbers of schooling are higher in Thailand, 6.1 years against 4.7 years in Indonesia, and the same holds true for tertiary education enrolment expressed as a proportion of the age group in question, 30 % in Thailand but only 11 % in Indonesia (Brimble 2003: 360; Hill 2004a: 33; Hill 2004b: 360-361; Shahid a.o. 2003: 203). In the early

1990s, science students constituted 0.32 % of the entire population in Thailand against 0.13 % in Indonesia (Wong and Ng 2001: 17). These scattered statistics all testify to a lead in terms of an upgrading of the labour force to facilitate a more effective absorption of new technologies.

Qualitative assessments by informed observers reinforce the emphasis given here on institutional and educational factors. In worldwide rankings on international competitiveness, Thailand scores better than Indonesia in technological sophistication in general and in production, R & D efforts and human research development in private firms, use of licensing, protection of intellectual property rights and, not least important, the quality of public education whereas Indonesia only surpassed Thailand with respect to the quality of scientific research and management education (World Economic Forum 2000). Again, a Thai lead above Indonesia may be identified albeit in rather qualitative or even intuitive terms than with clear-cut quantitative dimensions as in the ten-year time lag discussed on various occasions above.

8. Conclusion

Why has Thailand grown faster than Indonesia since the 1960s? Differential technological progress offers a more satisfactory explanation than initial conditions, factor endowment or long-run macroeconomic stability. The argument is supported by a brief survey of related topics such as factor productivity, structural change, access to new technology through foreign trade and investment, R & D expenditure and the institutional framework of technology policy. The twin theme of a time-lag hypothesis and country-specific characteristics of technological progress emerges from these discussions.

Indonesia lagged behind Thailand by about ten years, or slightly more, on several accounts including per capita GDP growth, value-added in manufacturing, exports of capital goods and application of medium- or high-level technology in manufacturing production. It is worth noting that some of these variables are directly connected to the pace of technological progress. The important question, however, is whether the observed difference is *more* than a time-lag, i.e. will Indonesia simply follow the Thai example in due course? To an extent this will surely happen but there is reason to suspect that other bottlenecks than in Thailand will have to be overcome. This brings us to the country-specific characteristics of technological progress.

It is demonstrated above that Thailand enjoyed, and still enjoys, a lead above Indonesia in total factor productivity, the extent of structural change, the orientation of FDI towards technology- and knowledge-based production and average educational attainment although differences in R & D spending appear rather marginal. This all points in the direction of a higher institutional efficiency in the process of technological progress in Thailand as opposed to Indonesia. By implication, Indonesia will have to make a concerted effort to overcome such difficulties in order to catch up with Thailand. Technology policy in Indonesia needs to address institutional weaknesses and, above all, shortcomings in the capacity of the labour force to absorb new technology. Measures to combat corruption and raise levels of educational achievement, both quantitatively and qualitatively speaking, are essential for Indonesia will it end up where Thailand has already arrived.

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