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Tigers and Pussy-Cats: The Importance of International Technology Transfer for Asian Felines

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1. Introduction

The impressive economic performance of a considerable number of East Asian countries in the after-war decades induced a mixture of awe, paranoia and disbelief in the industrialised countries. Developing countries, from their side, perceived a pattern to achieve high growth and swift industrial development.

Critics however rightly pointed out that the cultural, institutional and political differences between the East Asian countries were so large that it was not justified to fit the East Asian performance within a single unambiguous economic framework.

Professional sceptics like Krugman almost entirely ascribed the Asian growth performance to the accumulation of human and physical capital and claimed that there was little technological progress in most high-growth East Asian countries. Therefore, just like in the former Soviet Union, long term growth prospects were not perceived as bright as past performance might have led to expect.

Some may regard the Asian crisis as evidence of Krugman's view, who had already for some time predicted the Asian soap-bubble to burst.

In our view however, this position seems to disregard a number of indications of undeniable technological progress in East Asia and the convergence of some East Asian countries towards the level of the most developed countries and the attainment, by some, of the frontier in a number of high-tech domains.

In this paper we will first discuss the economic performance of the high growth East Asian countries and the different explanations to be found in economic literature.

Thereupon we will try to establish the role of international technology transfer in the economic growth process of East Asian countries, which transfer mechanisms were important and which differences there are between the countries.

2. The economic performance of high growth East Asian Countries

If we compare the growth data in table 1 of the eight HPAE¹ in the 1955-95 period to the figures for a number of OECD countries the growth performance of these eight East Asian countries can hardly be described as anything else than impressive. If this performance is compared to the development of other developing regions the continuity and regional concentration of the growth cannot possibly entirely be ascribed to coincidence.

The HPAE furthermore mark off with regard to the degree in which growth has been combined with a significant reduction in income inequality (Worldbank, 1993: p.2).

¹ Worldbank (1993) deals with eight so-called high-performing Asian economies (HPAE) : Japan, Hong Kong, (South-) Korea, Singapore, Taiwan, Indonesia, Malaysia and Thailand. In this category a distinction is made between forerunner Japan, the four Asian 'Tigers' (Korea, Taiwan, Hong Kong and Singapore) and the 'second-tier' countries Indonesia, Malaysia and Thailand. The Worldbank report does not deal with China although its high growth performance is acknowledged.

Table 1: Average GDP/capita growth in the 1955-95 period and GDP growth in 1998-2000²

1955-65		1965-75		1975-85		1985-95		1998	1999	2000	
HONG KONG *	9.7	SINGAPORE	11.3	HONG KONG	6.9	TAIWAN **	8.6	CHINA	7.8	6.6	7.0
JAPAN	8.3	KOREA	8.3	INDONESIA	6.5	THAILAND	8.4	TAIWAN	4.9	3.9	4.8
THAILAND	5.0	JAPAN	6.5	KOREA	6.3	CHINA	8.3	KOREA	-5.5	2.0	4.6
USSR *	4.9	TAIWAN	6.3	TAIWAN	6	KOREA	7.7	SINGAPORE	1.5	0.5	4.2
GERMANY	4.6	USSR	5.4	CHINA	5.3	SINGAPORE	6.2	HONG KONG	-5.1	-1.3	3.1
FRANCE	4.4	HONG KONG	5.1	MALAYSIA	5.1	INDONESIA	6.0	THAILAND	-8.0	1.0	3.0
TAIWAN	4.1	INDONESIA	5.1	SINGAPORE	4.8	MALAYSIA	5.7	FRANCE	3.1	2.2	2.9
NETHERLANDS	3.5	MALAYSIA	4.4	THAILAND	3.7	HONG KONG	4.8	GERMANY	2.8	1.5	2.8
BELGIUM	3.1	THAILAND	3.9	USSR	3.4	GERMANY ***	3.0	NETHERLANDS	3.7	2.3	2.6
SINGAPORE *	2.8	BELGIUM	3.7	JAPAN	3.1	JAPAN	2.9	INDONESIA	-13.7	-4.0	2.5
UK	2.3	FRANCE	3.5	UK	2.1	BELGIUM	2.2	BELGIUM	2.9	1.9	2.2
MALAYSIA	2.3	NETHERLANDS	3.3	US	1.9	NETHERLANDS	1.9	UK	2.1	0.7	2.1
US	1.9	CHINA	3.2	GERMANY	1.9	FRANCE	1.5	MALAYSIA	-6.8	0.9	2.0
KOREA	1.8	GERMANY	2.6	FRANCE	1.5	UK	1.4	US	3.9	3.3	2.0
CHINA *	1.0	UK	1.8	BELGIUM	1.3	US	1.3	JAPAN	-2.8	-1.4	0.3
INDONESIA *	-1.4	US	1.6	NETHERLANDS	1.1	RUSSIA	-5.1	RUSSIA	-4.8	-7.0	n.b.

* 1960-65 average

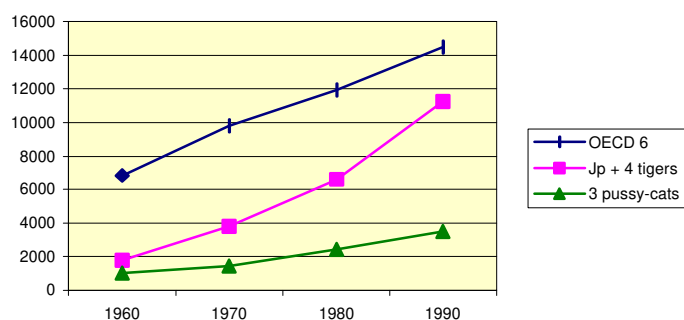
** 1985-90 average (Penn World data)

*** 1985-92 average (Penn World data)

Source: Own calculations from Penn World Data 5.6, Worldbank (1997) and IMF (1999)

IMF (1999) for most HPAE predicts growth figures for 2000, which with exception of Japan, Malaysia and Indonesia exceed predicted growth of the considered Western countries. If these predictions are anything to go by the East Asian countries seem to have reasonably smoothly recovered from the Asian crisis (Worldbank (1998), Fisher (1999) and The Economist (1999) all cautiously discern hopeful signs for most HPAE).

Figure 1 clearly reveals the catch-up in terms of GDP/ capita in the 1960-90 period of Japan and the four 'tigers' with regard to the group of six OECD countries from table 1 whereas the pussy-cats Indonesia, Malaysia and Thailand, despite strong growth, dropped behind with regard to the OECD-6 and even more so with regard to the other HPAE.

Figure 1: The evolution of average GDP (constant dollars 1985)/ capita for three country groups

Source: Based on Penn World Data 6.5

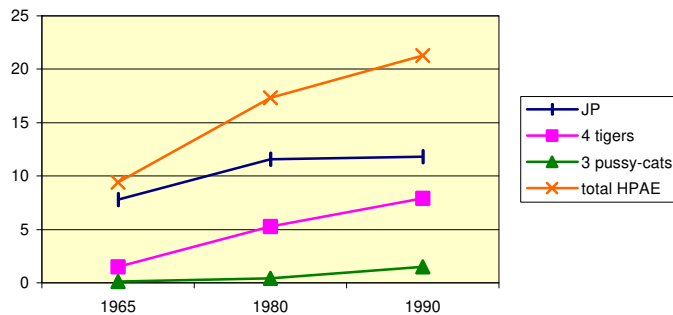
² Real GDP/ capita in constant dollars (1985), corrected for changes in terms of trade, for 1955-85 and average annual GDP/ capita growth for 1985-95 from Worldbank (1997). The figures for 1998, 1999 and 2000 are from IMF (1999). The numbers for 1999 and 2000 are predictions.

Figure 2 shows how the world market share of finished good exports of the HPAE more than doubled between 1965 and 1990. The world market share of Japan mainly increased between 1965 and 1980 and stagnated afterwards. The share of the 'tigers' has risen spectacularly while the 'pussy-cats' share remained modest notwithstanding a relatively large increase between 1980 and 1990.

The four 'tigers' have, in the wake of Japan, gained on the most developed countries to the extent that some of them reached the international frontier in a number of high-tech disciplines. Second tiers Indonesia, Malaysia and Thailand thus far do not seem to have caught with the West and their arrearage with regard to Japan and the 'tigers' even appears to have increased, if anything.

Obviously, compared to other developing countries the performance of these South East Asian countries is highly remarkable although the question remains whether to some extent their success can be explained by intraregional growth dynamics, that took off in North East Asia, and to which extent proper national characteristics can guarantee future economic growth and technological progress.

Figure 2: The evolution of the HPAE world market export share of commodities in the 1965-90 period



Source : Based on Worldbank (1993, p. 38)

3. Accumulation of human and physical capital and technological progress

The economic performance of the HPAE elicited differing reactions going from immoderate admiration over scepticism to inauspicious warnings of the 'yellow peril'.

From a theoretical perspective, diverging views were proposed to explain this strongly concentrated growth and swift development³.

In 1993 the World Bank publishes its much-discussed 'The East Asian Miracle'⁴, a report in which the performance of the fastest growing East Asian countries is demonstrated and explained. Although the HPAE did have some fundamental characteristics in common at the onset of their development the World Bank clearly states that it is questionable to talk about a single 'Asian model'. In table 2 the six factors that according to the World Bank help to explain a considerable part of the East Asian success are listed.

³ Landes (1999) even suggests that the success of HPAE in micro-assembly to some extent can be ascribed to the manual dexterity that comes from eating with chopsticks.

⁴ The report was brought about with the financial support of Japan which challenged the World Bank to put its development policy to the test of the development in the HPAE and more specifically to analyse the role and the effect of state interventionism (Fishlow en Gwin, 1994, p. 3-4).

In spite of the title of its report the World Bank does not consider the East Asian economic performance to be miraculous in the sense that it can be explained by a balanced policy focused on macro-economic stability and the promotion of investments in both physical and human capital. This view fits within the neo-classical growth theory which can explain how less developed countries can, through the accumulation of capital, catch up with developed countries which find themselves confronted with diminishing returns on capital.

Table 2: The six fundamental factors for explaining the East Asian performance according to the World Bank

<ul style="list-style-type: none"> • Macro-economic stability, low inflation and competitive rates of exchange • Building human capital • Effective and secure financial systems !!! • Limiting price distortions • Absorption of foreign technology • Limiting the bias against agriculture⁵
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Source: World Bank (1993)

The problem with this explanation however is why apart from East Asian countries so few developing countries actually succeeded in converging to the level of industrialised countries.

More recent, endogenous growth theory helps to explain how, due to dynamic economies of scale, the developed countries can extend their lead over developing countries.

This offers a possible explanation for the growing arrearage of most developing countries but can not explain the catch-up of Japan and the four tigers unless one considers important spillovers from the West.

The question then of course remains why only East Asian countries seem to have benefited from such spillovers.

For obvious reasons there exists unanimousness as to the importance for East Asian growth of macro-economic stability and the accumulation of physical and human capital (see a.o. World Bank (1993) and Asian Development Bank (1997)).

The World Bank however observes that the performance of HPAE can not entirely be ascribed to a well-considered 'liberal' policy and that most of these countries established a relatively high degree of state interventionism which, certainly where Northeast Asia is concerned, resulted in higher and more balanced growth than would have been possible without the state intervention (World Bank, 1993: p. 5-6).

Certain sectors were goal-directedly subsidised, exports were promoted and domestic markets of import substitutes were protected although the necessary foreign capital goods were imported without high taxes.

Governments highly invested in applied research and the transfer of knowledge between the public and the private sector was activated.⁶

The so-called 'revisionists' welcome that the World Bank admits that the HPAE growth performance cannot fully be explained within the neo-classical framework but regard its analysis and description as half-hearted.

Rodrik (1994) and Wade (1994) show some methodological shortcomings of the World Bank's analysis with regard to the selective promotion of specific sectors in a number of Northeast Asian countries. The World Bank considers this policy as unsuccessful whereas financial repression and export promotion are regarded as successful. Rodrik (1994) points out that the World Bank fails to make the distinction between a policy goal and policy instruments. The promotion of specific sectors which is a policy goal was pursued through policy instruments like granting credits and export subsidies. If the World Bank claims that the two policy instruments have proved successful this implies that the promotion of specific sectors for which those instruments were applied has also been successful.

Wade reflects on the possibility that the intraregional delocalisation of firms from Japan and the four tigers induced high growth afterwards in Southeast Asia. The acclaimed liberal policy towards FDI has led to considerable investments from Northeast Asian firms in Southeast Asia which resulted in a high dependence on foreign export-oriented MNE. Two thirds and more of Southeast Asian production is exported and is therefore not destined to the domestic market, which is more the case in Northeast Asia⁷.

Wade claims that Southeast Asian governments did too little to reinforce the link between foreign and domestic firms through which technology spillovers of FDI are limited and foreign firms operate within 'enclaves'.

Moreover these countries appropriated relatively few means to own R&D and education so that their chances of following their Northeast Asian counterparts in evolving from specialisation in labour intensive activities to more knowledge intensive high value-added activities seem rather slim and further economic growth is highly dependent on strategic decisions of foreign firms (Wade, 1994, p. 65-69)⁸.

Sarel (1996) distinguishes, apart from the 'neo-classics and 'revisionists', the 'agnostics' who claim the impossibility of measuring the effect of government policy on economic growth in East Asia and refer to the enormous differences between these countries with regard to the outlook and extent of state intervention (see a.o. Rodrik, 1994).

The assumption that exports and investments boosted economic growth can likewise not be proven in an unambiguous way because of the well-known problem of 'reverse causation'. High economic growth can equally well be assumed to stimulate exports and investments as the other way round.

⁵ In most countries the industrialisation process took place at the expense of investments in agriculture. This was however not the case in East Asia where notable investments have resulted in an increase in income and productivity in agriculture.

⁶ The HPAE made sure never to endanger economic stability and the budgetary balance. Public investment in these countries related to GDP, contrary to private investment, did not significantly exceed the level of other developing countries (World Bank, 1993: p.40-43).

⁷ In Malaysia foreign firms control 90 % of exports in machinery, electrical appliances, and consumer electronics (Wade, 1994, p. 66).

⁸ Puga and Venables (1999) describe a model that stresses agglomeration of economic development and the role of trade policy. They find that both import-substitution and free trade offers low wage countries the possibility to boost specific sectors. Free trade is in their model found to generate a larger welfare effect than import-substitution. The model focuses on the development of HPAE to show how industrialisation gradually evolved from Japan to Taiwan and Korea first and later on to 'second tier' countries like Malaysia.

For that matter, high investments and openness to trade were not characteristics that discriminated well between HPAE and other developing countries at the onset of the East Asian high growth era (Sarel, 1996, p. 16-20). Granger causality tests show that economic growth seems to predict saving rates better than the other way round (Worldbank, 1993, p. 242-45) and that for the ASEAN countries it predicts export growth better than the other way round (Ahmad en Harnhirun, 1996).

Bloom, Canning and Malaney (1999) estimate that demographic factors (e.g. growth of the active population) can explain one third up to one half of income growth in East Asia although here as well there is a problem of reverse causation. The authors acknowledge this fact and therefore mention the cycle of 'cumulative causality'.

A decrease in mortality as well as in fertility which first leads to an increase of the active population will in the longer term result in a greying population which can already be seen in Japan. This can hinder further growth and endangers the economic capacity of these countries.

Rodrik (1994) points out the problem of mutual causality and argues that an explanation of East Asian success probably lies in those characteristics that discriminated well between East Asian countries and other developing countries before the spectacular growth.

Rodrik examined for which parameters East Asian countries were significantly different from other developing countries at the onset of their growth.

Apparently, of the 41 countries that he considered, the poorer countries which had decent primary education, high life expectancy, low fertility and relative equal income and land distribution grew faster in the 1960-85 period than their counterparts. This conclusion was especially valid for the eight HPAE. Worldbank (1993) also reveals that the HPAE in 1965 scored higher on primary and secondary education level and participation than other developing countries. Education participation was higher than income per capita would have led to expect.

GDP growth in the period 1960-85 can, after exclusion of an endogenous variable such as investment, for a considerable part be explained by initial GDP per capita, income and land inequality and primary school enrollment⁹.

For Korea, Taiwan, Malaysia and Thailand the initial level of enrollment and inequality (negative correlation) explain 90% of growth (Rodrik, 1994, p. 22).

The importance of human capital, which is of course self-evident and undisputed, has also manifold been pointed out by Worldbank (1993).

With regard to income inequality the Worldbank showed that growth in the HPAE was allied to a decrease in income and land inequality ('shared growth') but did not take the point as far as Rodrik in suggesting that income equality may have been an important stimulus for East Asian economic growth.

Rodrik brings forward some arguments to found his position.

9 These results confirm the findings of Barro (1991), Mankiw, Romer and Weil (1992) and Barro and Sala-i-Martin (1995) on conditional convergence. They found that given a number of variables relating to education, life expectancy and government policy the rate at which a country evolves towards its 'steady state' is inversely related to its initial income level. These results seem to substantiate endogenous growth theory more than neo-classical growth theory although as Nelson and Pack(1999) point out the regressions that are used are not based on a specific model but rather on an 'eclectic' combination of all potential explanatory variables.

The existence of middle class can be important to ensure sufficient domestic demand.

Furthermore social tensions and the demand for income distribution in countries with high income inequality can stunt investment and endanger political stability.

Political and macroeconomic instability in Latin America can, from this point of view, partly be explained by the large income inequality (Rodrik, 1994, p. 23).

Apart from scholars which have tried to explain the HPAE growth performance from different angles some voices of sceptics resounded after the publication of 'The East Asian Miracle' with regard to the growth dynamic and long term growth perspective of East Asian countries .

In his 1994 article on the 'Myth of Asia's Miracle' Paul Krugman refers to the former USSR which, as can be seen in table 1, had a record of relative high economic growth for a couple of after-war decades. Krugman puts this growth down to accumulation of human and physical capital and the sacrifice of short term consumer interests to supposed long term growth. Because this growth entirely rests on an increase of inputs it will, due to decreasing returns to scale, come to an end or at least be slowed down.

According to Krugman the situation of East Asian countries is rather similar to the one of the former USSR.

Krugman rightly argues that persistent GDP per capita growth is only possible if output per unit input increases as a result of technological progress.

According to him East Asia does not show many signs of technological progress

Krugman founds his opinion on estimations of Kim and Lau (1994) and Young (1994) who conclude that the hypothesis that no technological progress occurred in East Asia cannot be rejected.

Technological progress is generally measured through 'Total Factor Productivity (TFP)', being the part of economic growth that can not be explained by labour or capital accumulation . Kim and Lau (1995) estimate TFP for Hong Kong, Korea, Singapore and Taiwan to be equal to 0.

By only referring to Kim and Lau and to Young Krugman neglects the Worldbank TFP estimations .

In Worldbank (1993) accumulation of labour and capital is estimated to contribute 2/3 to economic growth of HPAE. So, the largest part of the HPAE growth performance can indeed be explained by accumulation of production factors. Therefore accumulation explains, according to the Worldbank, the considerable difference between HPAE performance and the economic growth record of Latin America and Sub-Saharan Africa, which due to a lack of investment missed out on growth opportunities (Worldbank, 1993: p.53).

However, accumulation does not suffice to explain the catch-up of Japan and the four tigers or to quote Dowling and Summers : "While capital accumulation was critical to rapid growth it was only a necessary condition which had to be augmented by technological transfer" (Dowling and Summers, 1998: p.171).

Against the research cited by Krugman stand the results of the Worldbank and a number of other estimations which find considerable TFP contributions although there are enormous differences between the different estimations.

In a good survey on TFP estimations in Asian countries Dowling and Summers explain the diverging estimates by the high sensitivity to the period that is considered, the assumed capital share in income,

whether embodied technological progress is considered or not and also to the level of economic growth itself ¹⁰(Dowling en Summers, 1998: p.174-75).

They also argue that in the case of imperfect competition TFP is overestimated if embodied technological progress is not reckoned in input data. The existence of increasing returns to scale and the underestimation of increased labour quality can equally lead to overestimation of TFP.

However, even when input data are corrected Dowling and Summers find that data show that the contribution of TFP is higher for East Asian countries than for Western OECD countries. (Dowling and Summers, 1998: p. 171).

Sarel (1996) enumerates the unanswered questions that make that research which stresses the importance of accumulation and minimalizes the importance of technological progress in the HPAE are at best suggestive. Estimations are not very robust and very sensitive to the assumptions that are made by the researchers. He points out that Young (1994) uses a relative high value for the capital share and a specific period (1970-85) which decreases his estimation of TFP.

Chen (1997) argues that the fact that a number of studies find low estimations of TFP in HPAE, compared to Western countries, might be explained by an exaggerated correction of input data.

Worldbank (1993) clearly distinguishes between technological change, which relates to movements at the technological frontier, and technological efficiency which relates to the degree to which a country converges towards that frontier. TFP for developing countries is obviously mainly defined by technological efficiency which is a measure of catch-up.

The Worldbank estimates of technological efficiency discriminate between groups of HPAE countries. Productivity driven HPAE are characterized by high TFP contributions and positive technological efficiency estimates which reveals a catch-up with the Western OECD countries¹¹. This group contains Hong Kong, Japan, Taiwan and Thailand. The investment driven HPAE have low TFP and negative efficiency estimates and thus seem to lag behind with regard to the technological frontier. Singapore, Malaysia, Indonesia and to a lesser extent also Korea belong to this group (Worldbank, 1993: p. 57-58).

Striking in these results is the presence of two tigers in the second group and of 'second-tier' Thailand in the first group. Especially Singapore catches the eye with the by far most negative estimate of efficiency of all HPAE.

Singapore, for that matter, is the country Krugman points out to substantiate his claim that there has been little technological progress in East Asia. For Singapore estimates suggest that economic growth can almost entirely be attributed to accumulation of production factors. The Worldbank estimates however show that the situation of Singapore is not similar to that of other HPAE and that at least for a number of them there are undeniable indications of technological 'catch-up'.

Apart from that Collins and Bosworth (1996), Sarel (1996), Chen (1997) and Dowling and Summers (1998) find a high estimated TFP contribution to growth ($> 1/3$) for Singapore as well and Bosworth, Collins and Chen (1995) for the period 1986-92, Sarel (1997) for the period 1979-96 and Dowling and Summers (1998) for the period 1986-95 estimate TFP growth of Singapore to be the highest of all East Asian countries that are considered. Collins and Bosworth (1996) furthermore find that for 1984-94 the contribution of TFP to the growth of Singapore, Taiwan, Thailand and China has been higher

¹⁰ Furthermore estimates can differ because of the use of two different methodologies used for the estimation of TFP: regression analysis and growth accounting.

¹¹ There seem to be indications that China also belongs to this group.

than that of factor accumulation. Van Elkan (1995) estimates that in Singapore TFP raised GDP per capita with 76 percentage points in the period 1960-91. Bosworth, Collins and Chen (1995) find for the period 1986-92 high TFP growth for Singapore, Thailand, Malaysia and Taiwan and to a lesser degree for Korea and Indonesia. Sarel (1996) estimates that TFP growth and contribution was the lowest in Singapore of the four Asian tigers in the period 1975-90. His estimations suggest for the same period that TFP growth was higher in Japan and the four 'tigers' than in the US and contribution to growth was on average higher in Hong Kong, Taiwan and Japan than in the US and not considerably lower in Korea and Singapore.

For the period 1979-96 Sarel (1997) estimates of TFP growth are high for Singapore, Malaysia and Thailand and to a lesser degree for Indonesia. For the period 1986-95 Dowling and Summers (1998) find high TFP growth for Singapore, Taiwan, Thailand, Malaysia and Korea and again less so for Indonesia.

Let alone that the discussion on the high of TFP in HPAE so far, as should be abundantly clear from the foregoing, has not resulted in unequivocal conclusions Dowling and Summers rightly point out that even a small TFP contribution contributes more to growth in the fastgrowing HPAE than in the considerably more slowly growing industrialised countries.

Moreover the claim that East Asian countries have experienced little technological progress can hardly be reconciled with the observed export performance of a number of HPAE in high tech commodities and patent strength of Japan and more recently of Korea and Taiwan. As we can learn from (EC, 1997, p. 160-61) Korea and Taiwan appear in the top 3 in six out of eight considered disciplines with regard to the average annual growth (1986-95) of USPTO patents and Korea is in first place in four out of eight disciplines what average annual growth in EPO patents is concerned. Summing up, it seems fair to say that statistical 'reality' is still too diverging and problematic to resign in the tyranny of (some) numbers as Young (1995), and others with him, urges us to do.

4. The international transfer of technological knowledge and know-how to East Asia

There is evidence that the transfer of technological knowledge and know-how from the US and Europe contributed to the growth performance of HPAE and the technological catch-up of a number of them (e.g. Mowery and Oxley (1997) and Igel (1997)).

Looking at the different channels of technology transfer that have been important to East Asian countries one remarks the enormous differences between the HPAE so that again a single unambiguous model cannot be discerned.

Anyway, the channels through which technology is transferred seem less important than the factors that determine the absorption and diffusion capacity. This capacity which is primordial for the efficiency of technology transfer can be enforced through investment in own R&D, education and forma-

tion and policies that facilitate the absorption and diffusion between firms and between firms and research institutions¹² (See a.o. Pavitt, 1985, Igel, 1997, Mowery en Oxley, 1997).

Table 3 summarises the potential channels of international technology flows. In OECD (1990) technology transfer is defined more strictly than technology flows in the sense that for technology flows no contractual transaction is required as is the case for technology transfer. Technology transfer is therefore mostly restricted to licensing and agreements to transfer know-how¹³.

The question whether the transfer of knowledge from one company to another is intended or not and whether the transferor receives a compensation from the other company, seems within the frame of this paper less relevant¹⁴, although in the case of Foreign Direct Investment (FDI) the strategic motives of the investor are important for the degree to which the guest country can take advantage of the technological know-how of the investing firm (Dunning, 1994).

In what follows we will discuss the most important mechanisms of international technology transfer and try to verify which role they played in the HPAAE.

Table 3: International technology flows

Vehicle	International flow	Transactions
People	Education and training Personal contacts Professional mobility Technical cooperation Technical assistance between enterprises	Official technical cooperation Technical assistance agreements between enterprises
Documents Disclosed technology	Congresses, seminars, conferences Technical literature: patent data	Contracts with companies and engineering consultancies Patent licences
Appropriated and/or secret technology	(Pre) –feasibility studies and projects Drawings, plans Detailed engineering drawings	Equipment sales and purchases
Equipment and products	Machines, equipment, tools Turn-key plants	Direct investment in subsidiaries/joint ventures

Source: OECD (1990)

In figure 3 the time dimension of technology transfer is shown.

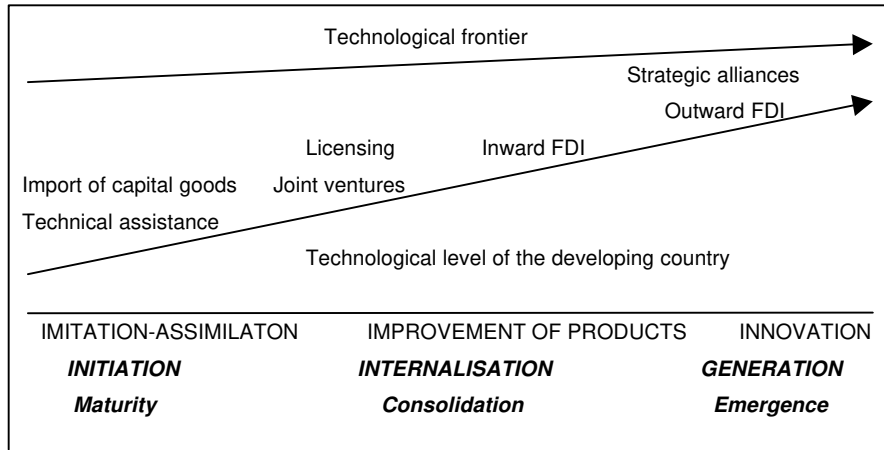
Kim and Dahlman (1992) and Ramanathan (1997) argue that according to the development stage at which a country finds itself, some transfer mechanisms may be more appropriate than others .

Ramanathan (1997, p. 38-39) distinguishes three stages in the development process. At the first stage (initiation) countries primarily use mature technologies to initiate their industrialisation. The most important mechanisms at this stage are the purchase of plants and equipment, technical information and expert services. Imitation and assimilation can possibly already be backed up by own R&D efforts.

¹² This point shows the importance of National Innovation Systems (NIS) which as networks between private and public R&D actors play an important role, not only by performing basic and applied R&D but also by diffusing research results and technological knowledge.

¹³ Throughout this text we use the less restrictive definition of technology flows, even when we use the word transfer.

Figure 3: Time dimension of technology transfer and technological catch-up



Source: Own drawing after Ramanathan (1997) and Kim and Dahlman (1992)

At the next stage (internalisation) mechanisms like licensing and joint ventures become more important as firms which transfer their technology will want to control its use. Multinationals will also more easily be tempted to invest in these countries as the technological level has increased and (labour) costs will still be relatively low. Own R&D efforts will focus on the development of new products or the improvement of existing products. Finally, at the last stage (generation) the firm (country) will have reached the technological frontier in a specific technological domain. Now, foreign firms will be reluctant to transfer their technology to firms (countries) that have reached this stage as these will now be (potential) competitors. Strategic alliances will become important mechanisms at this stage. Investing abroad will allow firms that have reached this stage to monitor technological progress in foreign markets.

Kim and Dahlman (1992) point out the opposite dynamic of the development of technologies and the technological evolution in developing countries. At the first stage of the development of technologies ('emergence') product technology evolves very rapidly with high technical and commercial risks. At the next stage (consolidation) it is process technology that evolves quickly which will result in a dramatic decrease of production costs.

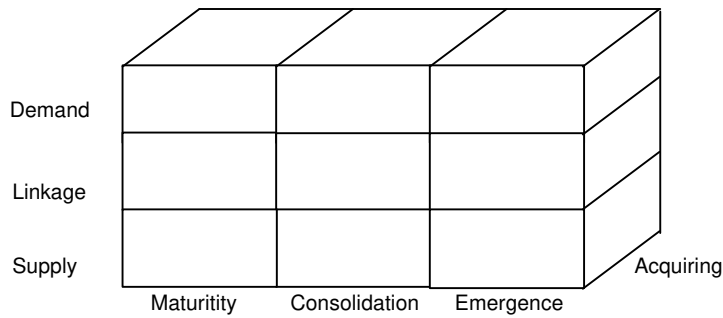
At the last stage (maturity) few improvements of products or processes are possible.

As mentioned before, developing countries will at the initiation stage of their industrialisation rely on mature technologies¹⁵, later on technologies in the consolidation stage and when they have reached a sufficient technological level on emerging technologies. Figure 4 reproduces the integrative framework developed by Kim and Dahlman to verify to which extent three perspectives (market mechanisms, technology flow and the dynamic perspective) fit in a 3x3x3-matrix where in each cell different policy instruments are appropriate.

In the figure we only reproduced the acquisition part of the technology flow perspective. The two other aspects (diffusion and own R&D) will not be covered in this paper.

Kim and Dahlman argue that government policy will only be successful to the extent that all its aspects and dimensions will be geared to one another.

¹⁴ The relevant question why a firm with superior technology might consider to sell or rent its technology to other, possibly competing, firms is for instance tackled by Ramanathan (1997, p. 25-7).

Figure 4: Integrative policy framework for the acquisition of technological know-how

Source: Kim and Dahlman (1992)

An important dimension in this analysis is time. Governments should use different instruments dependent on the development stage of the country or the firms.

In table 4 the cells are filled in for Korea. The last stage is not considered as according to Kim and Dahlman very few firms had reached this stage at the time of publication.

At the onset of the development process in Korea, importsubstitution has, on the demand side, improved the transfer of foreign technology in a number of sectors as firms heavily relied on foreign capital goods for their production. Exportpromotion pressured Korean firms to acquire foreign technology (Kim and Dahlman, 1992: p.442).

At the demand side considerable efforts have been made for the development of human capital and the import of capital goods were not subject to high tariffs.

Singapore and Hong Kong also had high imports of capital goods (Mowery en Oxley, 1997:p.150).

Table 4: The integrative policy framework for Korea

	Maturity (1960- 70s)	Consolidation (1980s)
Demand	Imports substitution Export promotion	Government procurement Revision IPR → increased demand for transfer through FDI and licensing Trade liberalisation
Linkage	Overvaluation of currency Tariff exemptions on imported capital goods Supplier's credits	Technology transfer center Technical information centers Public R&D institutes
Supply	Procurement of turnkey plants and capital goods	Liberalisation of FDI and foreign licensing

Source: Kim en Dahlman (1992)

The importance of FDI and licensing was at the first stage limited which can be explained by the restrictive policy of the Korean authorities as to that.

In the 1980s the international environment changed considerably, as a result of which Korea found it increasingly difficult to use instruments that had yielded good results in foregoing decades. Moreover, Korea had gradually reached the consolidation stage which prompted for different policy measures.

With regard to the changing international environment, the US and Europe took up a more protectionist position and pressurised for trade liberalisation. Due to serious wage increases the wage advan-

¹⁵ Western firms often shift their production facilities for mature technologies to developing countries as for these products cost minimization is of primordial importance. FDI might result in significant spillovers and the gradual

tage diminished. Foreign firms became more reluctant to transfer their technology to Korean firms and Western countries urged for more compliance with intellectual property rights. Because of the changed environment, which obviously also concerned the other HPAE, importsubstitution with protection of domestic firms, imitation and 'reverse engineering', which served Korea well at the first stage of its industrialisation, were replaced by FDI and foreign licensing. Korean government boosted demand by purchasing computers from domestic firms and by investing in the improvement of the network infrastructure. At the demand side participation to higher education was promoted but this does not seem to have prevented a considerable shortage of research oriented scientists and engineers (Kim and Dahlman, 1992: p. 446).

With regard to the linkage between supply and demand public transfer, information and R&D institutions were established. In the earlier stages of development these public institutes had been confronted with a lack of demand and their role was often limited to mere consultation.

The changed international situation makes it hard for countries that still find themselves at the maturity stage to use mechanisms that have been successful in some HPAE, but are no longer accepted.

The successive GATT rounds and the creation of the WTO reduce the possibilities of countries to pursue a restrictive trade policy whereas measures such as the TRIPS¹⁶ obstruct the possibility of imitation and 'reverse engineering' and force developing countries to conclude licensing agreements. However, restrictions on the licensor have also been included in the TRIPS agreement (Ramanathan, 1997: pp 42-43).

Kim (1997) discusses the spectacular emergence of the Korean semiconductor industry.

It hardly took Korea a decade to become a world market leader in memory chips. While this enormous jump start can partially be explained by advanced 'reverse engineering' and imitation the importance of FDI, mergers, acquisitions and strategic alliances on the one hand and own R&D efforts on the other hand is irrefutable (Kim, 1997, p.149-70).

Except from Japan, and perhaps Taiwan, Korea so far seems the only HPAE which succeeded in a short time to reach the technological frontier in a number of domains starting from a position of a low wage developing country, through a process in which channels of technology transfer gradually shifted, due to internal factors and government policy as well as changes in the international environment, from passive mechanisms like imitation and adaptation towards more active and interactive activities where innovation results both from own R&D efforts as from R&D efforts of counterparts. In the process Korea turned into a net supplier of technology.

In Table 5 we summarise the importance that the different channels of international technology transfer have played in the eight HPAE on the basis of literature that we consulted on the subject.

increase of the domestic technological level of the guest country.

¹⁶ Trade-Related aspects of Intellectual Property Rights: A GATT agreement that provides for a stricter compliance with IPR. Developing countries should comply with the conditions by 1st January 2000 and the least developed countries by the 1st January 2006.

The gaps in the table are due to a lack of information on a number of countries. If for a given country a cell is blank than this means that in the consulted literature we did not find any explicit information on the (non) importance of the given transfer mechanism for that country.

At the start of their industrialisation the import of capital goods has been of primordial importance to most HPAE.

Table 5: Importance of channels of international technology transfer to HPAE

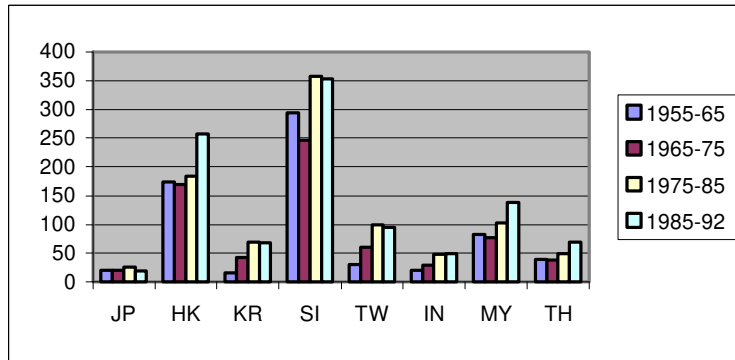
	Japan	Korea	Taiwan	Hong Kong	Singapore	Thailand	Indonesia	Malaysia
Inward FDI	Limited	Important	Relatively limited	Important	Very important	Relatively limited	Relatively limited	Important
Import-substitution	1950-60s	1950-60s	1950-60s	No	1959-65	1960-70s		Limited
Import of capital goods	Important (import often limited to 1 specimen)	Important		Very important	Very important	Limited		Limited
Reverse engineering/imitation	Important	Important	Important					
Export promotion		Important		From 1967		From mid 1980s		Important from 1970
Alliances, M&A	Important	Important (semi conductors)						
Licensing	Important in the beginning	Important (chemical industry, electrical and non electrical machinery)				Important		
Education/formation abroad	Very important	Important						
Outward FDI	Important	Important						

Source: Lynn (1985), Ozawa (1985), Westphal, Kim and Dahlman (1985), Worldbank (1993), Bercuson (1995), Kochhar a.o. (1996), Lichtenberg and van Pottelsberge de la Potterie (1996 a, b), Bae (1997), Kim (1997), Mowery and Oxley (1997) and Ramanathan (1997).

Countries like Hong Kong and Singapore pursued a very liberal policy as can be seen in figure 5. Other countries like Japan and Korea were much more restrictive with regard to import and heavily relied on importsubstitution. The description of the well-considered policy of Japan's MITI with regard to the import of capital goods, by Ozawa (1985) is very illustrative for this matter.

Usually only 1 type of a new capital good was imported while for the rest capital goods had to be purchased from Japanese producers, working under license of a foreign company. To ease the duplication and imitation of foreign capital goods important efforts were made of own adaptive R&D. Ozawa remarks that this policy, which in the long term can be regarded as very successful, was not appropriate according to the theory of comparative advantage as a country like Japan, that was highly endowed with labour but not with capital or raw materials, started to concentrate on capital intensive sectors (Ozawa, 1985, p. 230-1).

Figure 5: Average openness * for the period 1955-92



* (Exports+ Imports)/GDP

Source: Own drawing based on Penn World Data 5.6

As figure 5 reveals, openness to international trade is still not a criterion Japan scores high on.

In Korea as well, the import of capital goods was accompanied by import-substitution and the protection of the domestic market, the latter especially in favour of capital good users. Apparently, protection of domestic producers of machinery was limited before 1971 (Kim and Dahlman, 1992, p. 443).

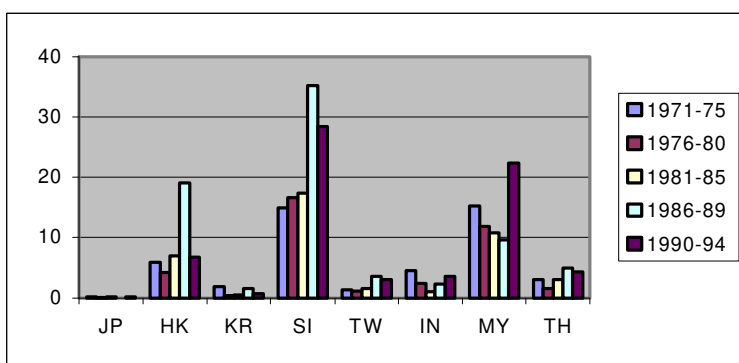
Figure 5 and 6 clearly show the high degree of correspondence between openness to trade and FDI. Singapore, Hong Kong and Malaysia are according to both standards the most open economies and Japan, Korea and Taiwan the most closed HPAE.

Caves (1974) discerns three potential benefits of FDI to the guest country: improvement of allocative efficiency, increase in technical efficiency and the technology transfer from the home country to the guest country.

However, FDI may exclusively relate to production for foreign or domestic demand without any transfer or technological spillovers in the guest country.

As mentioned before, Wade (1994) suggests that this may be the case in a number of 'second tier' HPAE.

Figure 6 : Average inward FDI/ Gross capital formation (%) in the period 1971-94



Source: Own drawing after UNCTAD 1992, 1996

Lichtenberg and van Pottelsberge de la Potterie (1996 a,b) do not find a significant effect of inward FDI on TFP for the OECD countries. The effect of outward FDI on the other hand is found to be significant in their estimations.

They estimate the output elasticity of foreign R&D efforts in the period 1971-90 for Japan to be relatively high in relation to the US, both with regard to import (.0719) and outward FDI (.0344) but that spillovers from other countries to Japan are almost negligible.

As Dunning (1994) argues, FDI will almost always benefit the technological level of the investing firm whereas the effect for the guest country highly depends on the motives of the investor.

On the other hand, Braconier and Sjöholm (1998), making use of more disaggregated data than Lichtenberg and van Pottelsberge de la Potterie, do find significant spillovers from inward FDI.

Asian countries participate more in alliances with US, Europe or Japan than with other developing Asian countries. The emergence of a Japan-centered bloc of alliances, excluding US or European firms, does not seem to be confirmed by the data (Mowery and Oxley 1997 : pp.147-8).

The phenomenon of technology-based alliances is still highly dominated by the Triad countries. These countries account for more than 80 % of alliances, although some smaller Asian countries are increasingly participating in international technology-based alliances (EC 1997 : p. 617).

As pointed out by Ramanathan (1997) joint research activities and strategic alliances are only an option to those firms in less developed countries that have reached an advanced technological level and is less obvious for firms and countries in an early stage of the development process.

5. Conclusion

The unprecedented high growth performance of the so-called high-performing Asian economies (HPAE), elicited diverging explanations.

The World Bank looks at the policies focused on macro-economic stability and investments in physical and human capital to explain a large part of economic growth in East Asia.

However, the World Bank admits that the HPAE performance can not entirely be ascribed to a well-considered 'liberal' policy and points at the relatively high degree of interventionism in most HPAE, which they, probably somewhat reluctantly, claim to have resulted in higher and more balanced growth, especially in Northeast Asia, than would have been possible without interventionism.

Some sceptics, like Krugman, doubt whether any real technological progress occurred in East Asia and believe that economic growth can almost entirely be explained by factor accumulation.

If the estimations they deduce this opinion from, are as yet anything but conclusive as to the real extent of technological progress, the claim as such seems hardly reconcilable with every day experience and a large number of indications that at least a number of HPAE have reached the technological frontier in a number of domains.

There is evidence that technology transfer from the US and Europe towards East Asia substantially contributed to the HPAE growth performance. As to the different channels that have been used to transfer or diffuse technological knowledge the stage of development is an essential factor. In the beginning of the industrial development process, import-substitution, reverse engineering and imitation

proved successful in countries like Japan, Korea and Japan whereas more 'liberal' countries like Singapore and Hong Kong relied more on the import of capital goods. In a later stage of development, when the technological level of the countries increased, licensing and inward FDI became more appropriate. The latter channels also became more significant because the successive GATT rounds and the pressure from the US and Europe to liberalise, reduced the possibilities of developing countries to rely on 'restrictive' or 'imitative' mechanisms.

As some of the HPAE have reached the last stage of development and caught up with western OECD countries, outward FDI and strategic alliances have become appropriate channels for the transfer of technology. Ultimately, a number HPAE have become net suppliers of technology instead of receivers.

Throughout the development process, HPAE have shown that investments in own R&D activities and human capital formation, i.e. investments in the absorptive capacity, are probably more important to economic growth than is the nature of the channels through which knowledge is transferred or spills over.

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