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Citation for published version (APA):

Jacob, J., & Szirmai, A. (2006). *International trade and knowledge spillovers : the case of Indonesian manufacturing*. (ECIS working paper series; Vol. 200601). Technische Universiteit Eindhoven.

Document status and date:

Published: 01/01/2006

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
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- The final published version features the final layout of the paper including the volume, issue and page numbers.

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Eindhoven Centre for Innovation Studies

**International Trade and Knowledge Spillovers:
The Case of Indonesian Manufacturing**

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Working Paper 06.01

Department of Technology Management

Technische Universiteit Eindhoven, The Netherlands

January 2006

International Trade and Knowledge Spillovers: The Case of Indonesian Manufacturing

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Abstract

The successful industrialisation and catch-up of countries in the East Asian region gave rise to an important debate concerning the role played by technological learning and knowledge creation. This paper seeks to examine this issue for Indonesia, a second tier Newly Industrialising Country (NIC). It focuses on the relative importance of learning from imported inputs vis-à-vis other factors influencing productivity in manufacturing. The concept of learning is operationalised drawing on the literature on technology spillovers on the one hand, and the literature on catch-up à la Abramovitz, on the other. Our results indicate that knowledge spillovers have become significant contributors to labour productivity growth after the liberalisation of the Indonesian economy.

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1. Introduction

The successful catch-up and late industrialisation of the East Asian region has been the topic of a much-celebrated academic debate in recent years. One of the central issues in this debate was the role of technology vis-à-vis factor utilisation in the “East Asian miracle”. Scholars who questioned the role of technology backed up their claim with Total Factor Productivity estimates that showed very low contributions to economic growth (Young 1994). In his, now well-known, article in *Foreign Affairs* Krugman (1994) provided wide popularity to this so-called *accumulationist* theme.

However, scholars of a different hue - assimilationists – dismissed the accumulationist view of industrialisation in East Asia by stressing the role of innovation, learning and entrepreneurship. They questioned the accumulationist hypotheses on a number of grounds. Authors like Nelson & Pack (1999) and Rodrik (1997) pointed out the shortcomings of the estimation procedures underlying the productivity figures that the accumulationist school relied upon. Historical case studies also identified learning and innovation, in particular in association with imported capital goods and intermediates, as the major ingredients of growth in NICs (Amsden 1989; Hikino & Amsden 1994; Kim 1997; Kim 1999; Westphal, Kim, & Dahlman 1985). This approach with its institutional focus also pointed to the significance of an incentive structure created by the state, where export-success is the principal yardstick for state-support.

Against the backdrop of this debate, the present paper focuses on the role of international technology spillovers and learning in the process of Indonesian industrialisation. Indonesia is a second-tier NIC, which reduced its dependence on oil and successfully started exporting manufactured goods since the late 1980s. Indonesian firms perform very little research and development and Indonesian industrialisation is highly

dependent on imports of capital goods and intermediate inputs from the advanced economies. While these imports can promote accumulationist patterns of growth, they can also contribute to technological learning and assimilation of internationally available knowledge.

This paper pursues the following objectives. First, what was the relative contribution of technological learning from imported inputs to labour productivity, compared to other factors, in particular, capital deepening; and what was the contribution of technological learning from exports? Second, to what extent has the shift from import-substituting to export-oriented industrialisation during the mid-eighties affected the relative contribution of technological learning compared to other factors? Finally, to what extent does the importance of technological learning vary across industries that differ in their technological intensities? To examine these issues, we construct a new measure of North-South knowledge spillovers, using OECD and Indonesian sources of data.

In the following section we highlight some features of growth in Indonesia in the last three decades to provide a background for testing the late industrialisation hypotheses of assimilationists and accumulationists. In Section 3 we present our empirical model and discuss some of the conceptual issues pertaining to the measurement of international knowledge spillover stocks. Section 4 briefly discusses the Indonesian and the OECD data sets, and the adjustments made to them. The estimation methods and the results are presented respectively in sections 5 and 6. Section 7 concludes.

2. Indonesian Industrialisation through the East Asian Looking Glass

Industrialisation in Korea and Taiwan started with an import substitution phase, followed

by a switch to export orientation around 1960 (e.g. Kiely, 1998). Initially, the export-drive was based on comparative advantage in labour intensive and low-tech lines of production. At a later stage, a process of technological upgrading commenced characterised by shifts into high-technology industries, use of skilled labour and the importance of learning (Amsden 1989).

Indonesia differs from East Asia due to her abundant natural resources, especially oil and gas and wood, and on account of the much later timing of the shift from import substitution to export orientation. Until the mid-eighties, it followed an import-substituting, export-pessimistic strategy of industrialisation, in sharp contrast to Korea and Taiwan, which by then had already long adopted strategies to boost manufacturing exports. Private sector participation was minimal and export earnings came to a very large extent from the booming oil and mining sector; the latter accounted for 77.6% of total export revenues in 1980.¹ Industrial policy during the “new order” regime of General Suharto had also placed emphasis on the development of scale intensive industries like automobile assembly, metal fabrication, steel and heavy engineering, utilising the revenues from oil & gas. However, the most important industries were resource intensive industries such as food, beverages & tobacco and rubber. These industries also accounted for bulk of the exports from manufacturing until the mid-eighties.

Given the prevailing ownership and incentive structures, large enterprises did not have to fulfil any export commitments, in marked contrast to their Korean counterparts. Again, unlike in Korea, the Indonesian industry faced the constraint of limited technological and

human capabilities (Hill 1995). These may explain the failure of such ambitious endeavours like, for example, the aerospace and automobile projects.

The steep fall in oil prices, first in 1982 and thereafter in 1986, led to the initiation of far-reaching economic reforms and the adoption of an export-oriented industrialisation strategy (Hill 1996). During the liberal era (1986—present), manufactured exports became the top priority of economic policies, similar in spirit to those in Korea and Taiwan. By 2000, the share of manufacturing in GDP in constant 1983 prices had risen to 27 per cent, from 10.9 per cent in 1975, and its share in total exports increased from 9.4 per cent to 55.1 per cent.

During the initial years of reform during the eighties, the emphasis has been on labour intensive and low-technology industries, as was the case in the early stages of export orientation in Korea and Taiwan. This marked a shift from the heavy industrialisation-drive of the import substitution period, towards labour intensive, low-tech and resource intensive industries in which Indonesia had a comparative advantage. Till the early nineties manufacturing exports were largely concentrated in three industries – wood and furniture, garments & leather products, and textiles –, which accounted for more than half of total manufacturing exports.

¹ Own calculations derived from an analysis of structural change in Indonesia, based on successive Indonesian IO tables from 1975 to 2000, in constant 1983 prices.

From the nineties onwards a more diversified pattern started to emerge, with products such as electronics, electrical goods and office equipment making substantial inroads into export markets. The export orientation of the post-reform phase has been assisted by a surge in investment from the Asian NICs and Japan. Nevertheless, within Indonesian high-technology industries the emphasis is still on low-value added activities, most of which resulted from the relocation of manufacturing activities from the Asian NICs, where labour costs were rising.

A moot question at this point concerns the contribution of technological learning toward Indonesia's industrialisation? Available evidence points to the exceedingly low levels of domestic private sector R&D, and limited cooperation between public R&D institutions (that account for bulk of the domestic R&D) and the private sector (e.g. Lall 1998). This raises the question whether Indonesia was able to profit from international inflows of technology through FDI, imported inputs and capital goods, and exports.

There is very little evidence of strong FDI-related technology spillovers. Although a recent econometric study at detailed industry level finds the presence of domestic spillovers from MNCs, the degree of foreign ownership has either no or in some cases a negative spillover effect (Takii 2005). It may be noted in this context that, earlier investigations based on case studies by Hill and Thee (1988) and Thee (1991) have shown no strong evidence for such spillovers.² The low learning from FDI may partly be due to low absorptive capacity.

² Hill and Thee (1998) and Hill (1996) provide elaborate accounts of Indonesia's industrial technology landscape. An earlier econometric study by Sjöholm (1999) does suggest the existence of spillovers. This study, however, does not fully exploit the panel nature of the data, which may have affected the results.

On the productivity contribution of exports, case studies on the garment industry of Bali and the furniture industry of Jepara show exports acting as an important channel of technology transfer (Thee 2003). However, econometric examinations of the manufacturing sector as a whole find little evidence for the spillover effect of exporting (e.g. Takii 2005).

This paper focuses on a potential alternative source of foreign technology spillovers, namely imports, which has so far not been sufficiently investigated in a developing country context.³ Manufacturing imports (of intermediate inputs and capital goods) account for about three quarter of total imports to Indonesia, and more importantly, imported capital goods fulfil almost 80 per cent of the domestic capital good requirements. It is unlikely that concerted learning efforts from imported inputs could have taken place in Indonesia on the same scale as in Korea. However, knowledge-spillovers from imports do merit closer attention in such an import dependent economy, especially in the more competitive post-reform period. In examining the role of imports in generating foreign R&D spillovers, we apply the theoretical and empirical notions of spillovers drawn from the literature on, on the one hand, endogenous growth and technology spillovers, and on the other, catch-up and appropriate technology, and develop a measure for capturing north-south spillovers. Subsequently, we also examine the role of export-related spillovers. In the following section, we discuss some of the conceptual and empirical issues pertaining to spillovers.

³ Technology contracts between domestic and foreign firms are an important channel of north-south technology diffusion. Unfortunately, for Indonesia data on technology contracts are not available.

3. The Model and Conceptual Issues

The starting point of our analysis is the following augmented Cobb-Douglas production function similar to Romer (1986):

$$Y_{it} = AK_{it}^{\alpha} L_{it}^{\beta} KS_{it}^{\lambda} e^{\varepsilon_{it}} \quad (1)$$

where Y_{it} represents the value added of industry i at time t , K and L represent capital and labour inputs respectively and KS the international knowledge stock. No term has been included for the domestic knowledge stock. Available evidence suggests very little R&D investment by the domestic private sector (e.g. Lall 1998).⁴ The theoretical model assumes that the production function exhibits constant returns to scale in capital and labour and increasing returns when the 'economy-wide technology capital'—in our case, the indirect international R&D stock—is included as a third factor. From (1), we derive an equation of labour productivity of the following type:

$$y_{it} - l_{it} = a + \alpha(k_{it} - l_{it}) + \eta l_{it} + \lambda ks_{it} + \varepsilon_{it} \quad (2)$$

In the above equation, lower case letters represent natural logarithms of variables, and η denotes the returns to scale parameter equal to $(\alpha + \beta) - 1$. As the returns to scale coefficient is determined econometrically, the assumption of constant returns to scale in capital and labour can be tested empirically.

The knowledge stock variable is designed to indicate the importance of international knowledge spillovers from imports and exports. The following section provides a

⁴ In contrast to other Asian NIEs, public research laboratories undertake the bulk of R&D spending in Indonesia. However, the R&D undertaken in these research laboratories has primarily been product certification, training and testing activities rather than R&D proper. Some data on R&D investment is available in our data set for a few years in the 1990s, but only a few plants have reported their R&D spending.

background to our notion of international knowledge spillovers and proposes methods for measuring it. We will distinguish between knowledge stocks deriving from imports and knowledge stocks deriving from exports.

Technology Spillovers

Technology exhibits certain public good characteristics, which enable firms or industries, which are technologically *close* to each other to benefit from each other's research efforts. This can be by means of licensing⁵, reverse engineering, the exploitation of knowledge from patents and academic and trade journals, mobility of researchers, imitation and so forth. Griliches (1979) refers to this form of technology diffusion as 'true' externalities (knowledge spillovers), and distinguishes it from rent spillovers. Rent spillovers arise when quality improvements due to R&D are not fully reflected in the prices at which goods and services are sold by upstream suppliers to downstream producers/customers due to competition in the product markets. Thus, within the confines of a single economy, rent spillovers amount only to an unwanted measurement problem, as productivity improvements in supplying industries show up in the productivity statistics of a downstream industry.⁶

The notion of knowledge spillovers encompasses the concept of learning, the importance of which we set out to examine in this paper. There is a voluminous literature on the contribution of knowledge spillovers to productivity (e.g. Los 1999; Verspagen

⁵ Like the purchase of technology-embodied inputs, licensing can only generate true knowledge spillovers if the purchaser is able to *add* to the technology or knowledge that is licensed through complementary research effort and learning.

⁶ Rent spillovers do contribute to our further understanding of the sources of productivity growth and the identification of the driving industries.

1997) and its role in generating social returns to R&D that exceeded private returns (e.g. Bresnahan 1986; Jaffe 1986). Studies have also underlined the importance of knowledge spillovers between firms, industries as well as countries as an important component of technological progress.⁷

The diffusion of technology from advanced economies to developing countries has also been the subject of extensive investigations, with studies focusing on different channels of technology diffusion. Spillovers resulting from technology purchase and FDI have been found significant to the productivity performance of Indian manufacturing firms by Basant and Fikkert (1996) and Kathuria (2002), respectively. These studies also underline the importance of complementary domestic R&D effort for benefiting from spillovers. In their analysis at the aggregate level, Coe, *et al.* (1999), found that imports of machinery from advanced countries, especially from the USA, have been an important contributor to domestic TFP growth for a sample of 77 developing countries.

Unlike studies in the OECD context, those in the North-South context have seldom made a distinction between rent spillovers and knowledge spillovers. This is obviously due to the difficulties involved in their measurement. From a theoretical point of view it is not difficult to see how imports can generate knowledge spillovers. Firstly, reverse engineering and learning by using allow the buyers to generate spillovers of knowledge from the technologies embodied in imported inputs. Secondly, trade enables local firms to interact with their suppliers in advanced economies. As von Hippel (1988) argues, supplier-producer interaction is mostly of the 'idea-creating' type. Finally, exports can be

⁷ For a review of literature that examine studies on technology spillovers in general and rent and knowledge spillovers in particular, see Los (1999).

an important source of technological learning as exporting firms have to learn to meet international quality standards on product markets (Lall 1992; Kim and Nelson 2000).

Spillovers from Imports: Deriving the International Knowledge Stock

Since knowledge spillovers tend to take place between entities that are close to each other in a technological sense, empirical studies have attempted to develop patent-based measures that capture what is called technological distance (Jaffe 1986; Verspagen 1997). While we use this notion of technological distance in deriving the international R&D stock, we also introduce a new measure of technological similarity of industries, based on inter-country comparisons of input structures.

We derive our measure for international knowledge stock in Indonesia in four steps. First, industry-level R&D stocks are calculated for each advanced trading partner of Indonesia in the OECD using the perpetual inventory method (PIM). Second, we weight R&D intensity (R&D stock per unit of output) at the industry-level in these countries by the volume of their exports to Indonesia. Third, we weight the resulting figure by an index of technological distance between the industry of origin and the industry of destination. Finally, we weight the result with an index of technological congruence between the same industry in the advanced economy and Indonesia.

Step 1: Industry-level R&D Stock of Partner Countries

The starting point in constructing the international R&D stock is the construction of industry-level R&D stocks for countries that export to Indonesia. We consider 10 major

trading partners of Indonesia in the OECD.⁸ The countries considered are Australia, Canada, Denmark, France, Germany, Great Britain, Italy, Japan, the Netherlands and the USA. We derive industry-level R&D stocks for each country in constant prices using PIM (with the benchmark year taken as 1973), assuming an annual growth in R&D stock of 5% and a depreciation rate of 0.15.

Step 2: International R&D Stocks

The contribution of an advanced country's industry-level R&D stock to the International R&D stock in Indonesia is assumed to depend on its exports to Indonesia. It is calculated by weighting the R&D intensity (R&D stock divided by output) at the industry-level of the advanced country by its exports at the industry-level to Indonesia:⁹

$$ERD_{ci}(t) = RD_{ci} E_{ci}(t) \quad (3)$$

in which ERD_{ci} is the export-weighted international R&D stock from industry i in country c to Indonesia; RD_{ci} the ratio of the R&D stock to output of industry i in country c , and E_{ci} the volume of exports from industry i in country c to Indonesia.

Step 3: Potential Knowledge Stocks

The next issue is the distribution of this export-weighted R&D stock across Indonesian industries. Since we are concerned with the flow of 'pure knowledge' in the sense of Griliches (1979), we need some measure of technological closeness between the receiving and emitting industries. The assumption is that the 'closer' are two industries to each other in a technological or economic sense, the more the receiving industry can

⁸ Our sample of 10 countries account for about 85% of the R&D expenditure by 15 OECD countries, which in turn account for, according to Coe and Helpman (1995), roughly 90% of the global R&D.

⁹ For a discussion of the use of trade weights, see Lichtenberg and van Pottelsberghe de la Potterie (1998).

profit from the technology flows emanating from the other industry. In the literature such closeness/distance-measures are derived, amongst others, from the type of performed R&D, the qualifications of researchers, the distribution of patents between patent classes, and so forth.

We use a patent-based measure of technological distance derived by Verspagen (1997) from the EPO (European Patent Office) data. The European patent office assigns each patented invention to a single ‘main technology class’, and one or several ‘supplementary technological classes’. The main technology class is assumed to represent the knowledge-generating industry and the supplementary technology class is assumed to represent knowledge-receiving industry. A concordance scheme between the technology classes (IPC codes) and industries (ISIC, Rev.2) assigns the main technology class and the supplementary technology class to industrial codes. These two classes of industries can be linked with the ‘emitting’ industries in the rows and the ‘receiving’ industries in the columns. From the resulting matrix, we can derive a technological distance matrix by dividing the number of patents in each cell by its row total. We represent this technological distance matrix by P , with the element P_{ij} representing intensity of knowledge flow from industry i to industry j . We use this measure to weight the international R&D stocks to derive the stock of knowledge in a given industry from all the other industries (including itself), which we call the *potential knowledge stock* in each of the Indonesian industries.

This potential knowledge stock can be expressed as follows:

$$PKS_{-m_{cj}}(t) = \sum_i ERD_{ci} P_{ij}(t) \quad (4)$$

where, $PKS_{-m_{cj}}$ is the potential knowledge stock in industry j of Indonesia associated

with imports from all industries i of country c

In the above equation, ERD_{ci} captures the stock of International R&D transmitted through trade to the Indonesian manufacturing from industry i in country c , and the patent information flow matrix P shows the inter-industry distribution of this R&D stock.

Step 4: Actual International Knowledge stock: Using the Structural Congruence Index as Weight

A weakness of the indicator resulting from step 3 is that it assumes that inter-industry technology flows are the same across countries. This is even more problematic when comparing manufacturing industries of developed countries with those of a developing country. That is why we refer to the measure resulting from step 3 as a potential knowledge stock. The question is how a potential knowledge stock is transformed into an actual knowledge stock.

The significant departure of this paper from the existing literature is that we add a measure of technological congruence to account for inter-country differences between the same industries. Our notion of technological congruence is linked to the idea that an industry in a follower country benefits more from the global pool of technology, the greater its technological congruence with industries in advanced countries (Abramovitz 1989). A related idea is that of appropriate technology due to Basu and Weil (1998), which states that a developing country may refrain from using a new technology until it reaches the level of development at which this new technology is appropriate to its needs. This is because technologies are specific to a particular combination of inputs, and potentials for learning (by doing) is limited if there is a wide mis-match between the current input-mix and that warranted by the new technology. Technological congruence,

thus, provides an indication of the absorptive capacity of an industry in a developing country. The greater the technological congruence, the more likely a country is able to absorb technology and to transform a potential knowledge stock into a real knowledge stock.

We derive a country-by-country technological congruence index by comparing the input structure (column vector of input coefficients) of an Indonesian industry with the input structure of the same industry in each of her 10 trading partners in the OECD. This measure allows us to distinguish the potential knowledge stock in a given industry (as derived from technological-distance measure) from the actual technology spillover to that industry.¹⁰ This implies that given the level of potential knowledge stock in an industry from imports, an increase in the industry's structural congruence with the same industry in the exporting country will lead to an increase in the indirect R&D stock

Incorporating the technological congruence measure into equation (4) yields the following:

$$KS_m_j(t) = \sum_c PKS_{cj} S_{cj}(t) \quad (5)$$

where KS_m_j is the realised indirect knowledge stock resulting from international knowledge flows in industry j of Indonesian manufacturing from all industries of each trading partner country. S_{cj} is the technological congruence weight between the industry j of Indonesia and the same industry of her partner country c .¹¹ It can be written as follows:

¹⁰ van Meijl & van Tongeren (1999) show that a higher technological embodiment can be counter-balanced by the structural differences between the receiving and supplying entities.

¹¹ The input coefficient vector of an industry, derived from 'total' intermediate input vectors can be argued to represent the technology of that industry. See Los (1999) on the appropriateness of using input coefficient vectors to measure technological closeness. The technological congruence weight in equation (6) is based on the formula used by Pearson (1994). He constructed inter-country export similarity indices

$$S_{cj}(t) = \sum_j \min(A_{dj}, A_{cj})(t); \quad 0 \leq S_{cj} \leq 1 \quad (6)$$

where, A_{dj} and A_{cj} are column vectors representing respectively the share in the column sum of the input coefficient vector for industry j of Indonesia (d) and the trading partner (c). S_{cj} takes a value of 1 if the two industries are perfectly similar and zero in the case of perfect dissimilarity between them.

Spillovers from Exports: Deriving the International Knowledge Stock

Like imports, exports can also generate knowledge spillovers. Exporting creates contacts with foreign markets, and with new sources of knowledge, such as foreign buyers. As noted earlier in the paper, exporting also increases the incentives to acquire technology to meet the demands and standards of global markets, in the face of international competition. As with imports, exporting to technologically more sophisticated markets presumably generates more spillovers of knowledge than exporting to markets where quality considerations are less important and the technological base is relatively low. In line with this argument, we construct a knowledge stock to capture spillovers from exports as follows:

$$KS_{x_j}(t) = \sum_c RD_c E_{jc}(t) \quad (7)$$

in which KS_{x_j} is the indirect knowledge stock in manufacturing industry j of Indonesia resulting from its exports to the 10 trading partner countries in the OECD, discussed in

to compare the export structures of several Asian economies.

the previous section; RD_c the ratio of the R&D stock to output of the manufacturing sector in country c , and E_{jc} the volume of exports from industry j in Indonesia to country c .

Expanded Model

We now expand equation (2) to include other theoretically important variables that can influence labour productivity, namely foreign ownership, industrial concentration, a liberalisation dummy and time, as follows:

$$y_{it} - l_{it} = a + \alpha(k_{it} - l_{it}) + \eta l_{it} + \zeta ks_m_{it} + \rho(ks_m \times hn)_{it} + \theta ks_x_{it} + \delta f_{it} + \gamma T + \psi d + \varepsilon_{it} \quad (8)$$

where, hn is the Herfindahl index of industrial concentration, f the share of foreign controlled plants in output, T the time trend, d the dummy variable for liberalisation and $ks_m \times hn$ the interaction term between the international knowledge stock from imports and the Herfindahl index of domestic concentration; the latter index is normalised for the number of plants. It is defined as follows:

$$Hn_{(t)} = \frac{nS - 1}{n - 1}_{(t)}, \quad 0 \leq Hn \leq 1$$

where, $S = \sum_i s_i^2$, s_i is the market share of the i^{th} plant and n is the number of plants in the industry.

The conditional causal effect of import spillovers on labour productivity is now given by $\zeta + \rho(hn)$. We assume that some degree of concentration is conducive for learning and innovation from the perspective of *Schumpeterian theories of growth*.¹²

¹² It has to be admitted, however, that evidence on this Schumpeterian notion is mixed in the empirical literature (see, Cohen and Levin, 1989).

Variable f in the equation is the average output-share of foreign-controlled plants in an industry.¹³ This variable is meant to capture the contribution of knowledge spillovers from MNCs to their subsidiaries and to local firms. We have included a time trend T in the equation, which captures exogenous factors contributing to productivity. Finally, d is a dummy variable that accounts for the effect of economic liberalisation on the intercept term of the regression equation.

4. The Data

Our study combines Indonesian data sets on production and input–output transactions with the R&D, export-to-Indonesia, export-from-Indonesia, output and input-output (IO) tables of 10 major OECD countries that trade with Indonesia. Table 1 shows the 19 sectors used in the study. The final column shows the technology class to which each sector belongs. The data set used in the analysis is a panel, consisting of 19 manufacturing industries for the period 1980-1996 (323 observations). All variables are measured at constant 1990 international PPP dollars. Below we explain the key aspects of the Indonesian and OECD data sets, followed by a discussion on the data used for constructing inter-industry weights.

The Indonesian Data

We use the BPS establishment-level data sets, SI and backcast data, to build all variables

¹³ We define foreign controlled plants as those with a foreign ownership of 10 % or more. This based on the International Monetary Fund (IMF) definition that ‘... an ownership of at least 10 %, implies that the direct investor is able to influence, or participate in, the management of an enterprise. Absolute control is not required.’

other than the spillover stock. While the backcast data cover a larger sample of establishments, especially before 1985, they provide information on only a few variables such as gross value added, employment and output (see Jammal (1993) for details on the backcast data).

TABLE 1 *Sectoral Classification*

Sector	ISIC Revision 2	Technology class ^a
Drugs & medicines	3522	1
Radio, TV & communication equipment	3832	1
Professional goods	385	1
Industrial chemicals	351+352-3522	2
Rubber & plastic products	355+356	2
Non-electrical machinery	382	2
Electrical apparatus, nec ^b	383-3832	2
Shipbuilding & repairing	3841	2
Other transport	3842+3844+3849	2
Motor vehicles	3843	2
Food, beverages & tobacco	31	3
Textiles, apparel & leather	32	3
Wood products & furniture	33	3
Paper, paper products & printing	34	3
Non-metallic mineral products	36	3
Iron & steel	371	3
Non-ferrous metals	372	3
Metal products	381	3
Other manufacturing	39	3

^a 1 = high technology sector; 2 = medium technology sector; 3 = low technology sector.

^b nec = not elsewhere classified.

But the backcast data, apart from the wider coverage of manufacturing, is considered to be also qualitatively superior. We combined the SI data with the backcast data in order to make use of the variables reported in the former but not in the latter; the two series that were merged to the backcast from SI are investment and foreign ownership. First we merged establishments for which the two data sets show equal output, value added and

labour. Second, observations that did not match in the first stage were merged using establishment-identification codes.¹⁴ Finally, the non-matched backcast observations, which represented newly discovered establishments, were added to the matched data set. In this way we eliminated erroneous observations from the SI data.¹⁵

The Capital Stock Series

One of the serious problems with the data, and especially with the investment series, is the large number of missing values. To generate investment series for all establishments, we compared, for each year, the average value added–investment ratio at the 5-digit industry level of the ISIC with the value added data of the establishments for which investment data are missing. This exercise was undertaken for four types of investment series—building, machinery, transport equipment and ‘other assets’. For 1996, no investment data are available (although the database contains estimated total gross capital stock data, they were not used owing to comparability problems). We generated investment series for this year by comparing the incremental capital–value added ratio (ICVAR) for 1995 with the change in gross value added between 1995 and 1996.

We converted the investment series into constant 1990 prices using three types of price indices contained in the *Indikator Ekonomi* series published by BPS: a price index of non-residential and residential building to deflate investment in building; a price index

¹⁴ We followed this two-step merging procedure rather than stage two alone because the establishment identification codes are not completely accurate.

¹⁵ The two establishment-level data sets are beset with flaws such as duplicate observations, and even duplicate establishment-identification codes. Most of these result from the BPS practice of accounting for the missing data of establishments that do not report data for some years by using the data of establishments with similar characteristics.

of imported machinery for machinery and equipment; and a price index of imported transport equipment for vehicles and for other investment.¹⁶ The deflated series were divided by the purchasing power parity for 1990 (for comparability with the OECD data used). We then constructed a new capital stock series for the Indonesian manufacturing sectors (classified according to ISIC, Rev. 2) from 1975 to 1999. To derive benchmark capital stock data we used the ratio of the average ICVAR for 1976–80 (Dasgupta *et al.* 1995; Osada 1994; Timmer 2000). This ratio was then multiplied by the gross value added for 1975 to derive the benchmark capital stock for 1975. Based on this benchmark, we constructed a capital stock for the remaining years using PIM, using depreciation rates of 0.033 for buildings, 0.10 for machinery and equipment and 0.20 for vehicles and other fixed capital. These depreciation rates are based on the survey findings of Goeltom (1995).

The OECD Data

R&D, Output, Exports and Imports

We drew on OECD and World Bank sources for the data on OECD countries used in the construction of the international R&D stocks. The data on output, R&D and exports-to-Indonesia were derived from the OECD's STAN (structural analysis), ANBERD (analytical business enterprise research and development) and BTD (bilateral trade) data sets, respectively. The data on sectoral export of Indonesian manufacturing to the 10 OECD markets were extracted from the World Bank's 'Trade and Production (1976-1999)' data set. This data set contains 'mirror exports' (reported by trading partners), in

¹⁶ Aswicahyono (1998) and Timmer (2000) follow the same approach.

addition to the export data reported by the exporting countries themselves. We considered the quality of data on Indonesian exports reported by Indonesia's trading partners superior, and therefore, employed them in the study.

The R&D expenditure for each of the 10 OECD countries was converted to 1990 prices, and further into 1990 purchasing power parity dollars. R&D stock was then derived using PIM (with the benchmark year taken as 1973). Following common practice we assume an initial growth of 5% and a depreciation rate of 0.15% (e.g. Griliches and Mairesse 1984).

Data for Constructing Inter-industry Weights

Inter-industry distribution weights of R&D were derived from the IO tables of Indonesia and her trading partners. To construct our measure of structural congruence (for deriving the knowledge spillover stock from imports), we used the 'total' IO transaction tables in current prices of Indonesia and her 10 OECD partner-countries for the years 1980, 1985, 1990 and 1995. For Indonesia, we used the tables published by the BPS. The OECD tables were taken from the OECD IO database. Where a table for an OECD country for a particular year was not available, we used the IO table of the nearest preceding or following year. The similarity indices for the 19 manufacturing sectors were derived by comparing the Indonesian and OECD tables that were aggregated to a total number of 31 sectors. (Note that in calculating the bilateral similarity indices for manufacturing sectors, the intermediate-input deliveries from non-manufacturing sectors were also taken into account.) For countries like Germany, Denmark and the Netherlands, the original tables contain fewer sectors than for other countries. A few of the 19 manufacturing sectors considered in our analysis are missing in these tables. In these cases we followed an aggregation scheme which yielded a lower number of sectors; the similarity index

derived for the ‘nearest’ industry (belonging to a higher ISIC digit) was then used to represent that for the missing industry.

5. Estimation Issues

After having found that industry specific effects are correlated with the regressors, we choose for the panel data estimation model involving industry dummies (the so-called fixed or within effect model). We also make separate estimations for the pre- and post-liberalisation phases. Although the economic reforms began on a large scale from 1986 onwards, we consider the data till 1987 as belonging to the pre-liberalisation phase. This is based on the assumption that policies take effect with a lag. A *Chow test* showed that there was indeed a significant difference in the slope coefficients of the regression equations between the periods 1980-87 and 1988-96.¹⁷ This is so even after including a period dummy (to account for changes in the intercepts) in the regression equation for the full sample.

In addition to the division of sample between the pre- and post-liberalisation phases, we have also divided the sample into low-, medium- and high-technology industries.¹⁸ The estimation is therefore done using the full sample, as well as sub-samples for high-,

¹⁷ The calculated *F-statistic* is highest when 1987 is taken as the cut-of year, rather than 1985, 1986 or 1988.

¹⁸ This division is in line with the OECD classification. High-tech industries (ISIC rev 2 codes in brackets): drugs & medicines (3522), radio, tv & communication equipment (3832), professional goods (385). Medium-tech: industrial chemicals (351+352-3522), rubber & plastic products (355+356), non-electrical machinery (382), electrical apparatus not else where classified (383-832), shipbuilding & repairing (3841), other transport (3842+3844+3849), motor vehicles (3843). All other manufacturing industries are assigned to low-tech.

medium- and low-technology industries, for the complete period and the pre- and post-liberalisation phases.

An important question at this point is whether our results are affected by spurious correlation amongst the variables, which occurs when the variables are non-stationary. The empirical literature on spillovers cautions us of such a possibility (e.g. Los and Verspagen, 2000). To check whether the variables are non-stationary or not, we use the test for heterogeneous panels developed by Im *et al.*, (2003). The null hypothesis of non-stationarity is not rejected for all variables, except the interaction variable, $ks \times hn$. However, for the latter variable the unit root calculated from the ADF regression is about 0.959. Given this result and the low power of the unit root test as well as the short time-series dimension of the data, we consider this variable to be *near integrated* (Banerjee *et al.*, 1993). The conclusion that our variables are non-stationary implies that OLS fixed effects estimates will be biased and alternative estimation methods are required.¹⁹

We subsequently used the Engle and Yoo (1991) three-step procedure for long-run cointegrating relationships to estimate equation (8). In the first step we estimate a fixed effect or *within* regression of equation (8) (excluding the time trend and the period dummy). We then perform the Im *et al* (*ibid*) test on the residuals of this equation, and conclude that we have cointegration. The second step is the estimation of an error correction model (ECM). This involves estimating equation (8) in first differences, with the lagged value of the residual from the first step as an additional regressor (excluding the intercept term). A significantly negative coefficient for the lagged residual is another

¹⁹ The results of the fixed effect estimation are reported in the appendix.

indication of a cointegrating relationship, which we find in all our samples. The final step is the following,

$$\begin{aligned} \varepsilon_{it} = & \alpha_1(-\hat{\xi}(k-l)_{it-1}) + \eta_1(-\hat{\xi}(l)_{it-1}) + \zeta_1(-\hat{\xi}(ks_m)_{it-1}) \\ & + \rho_1(-\hat{\xi}(ks_m \times hn)_{it-1}) + \mathcal{G}_1(-\hat{\xi}(ks_x)_{it-1}) + \delta_1(-\hat{\xi}(f)_{it-1}) + \nu_{it} \end{aligned} \quad (9)$$

in which, ε is the residual from the second step and $\hat{\xi}$ is the estimated coefficient of the lagged residual in the second step. The lagged values of the right hand side variables have been used in the above equation under the assumption of weak exogeneity. The long run relationship is calculated as the sum of the coefficients in the first and third steps, and the unbiased standard errors are those from the third step.

One major problem associated with the Engle and Yoo (EY) estimation procedure is the considerable small sample bias due to mis-specified dynamics and simultaneous equation bias. Saikkonen (1991) suggested that the former could be alleviated by using the current first difference of the regressors and ‘sufficient’ lags of these differences; the latter problem is corrected by adding the leads of these differences. This procedure is referred to as Dynamic Ordinary Least Squares (DOLS).

$$y_{it} - l_{it} = a_i + \mu x_{it} + \sum_{j=1}^p \phi_j \Delta x_{i,t-j} + \sum_{j=1}^p \varphi_j \Delta x_{i,t+j} + \gamma T + \psi d + \varepsilon_{it} \quad (10)$$

In the above equation x represents the regressors in equation (8) (excluding T and d). We use a lag and lead of one year based on the Akaike Information Criterion.

A summary statistics of the variables used in the analyses are reported in table 2.

TABLE 2 *Summary Statistics*
(means, standard deviations in brackets)

	Observations	log (Q/L)	log (K/L)	log (KS_m)	log (KS_m×Hn)	log (KS_x)	log (F)
Full period, 1980-96							
Total	323	10.020 (0.776)	12.157 (0.993)	17.108 (1.324)	-52.265 (18.810)	10.628 (3.470)	2.902 (2.313)
High-Tech	51	9.744 (0.575)	11.716 (0.972)	18.079 (0.589)	-48.712 (15.719)	10.699 (2.638)	2.199 (4.581)
Med-Tech	119	10.204 (0.646)	12.032 (0.607)	17.672 (1.385)	-49.274 (17.098)	8.755 (3.837)	2.835 (2.237)
Low-Tech	153	9.968 (0.888)	12.401 (1.164)	16.346 (0.980)	-55.776 (20.437)	12.049 (2.655)	3.188 (0.540)
Pre-Liberalisation Phase, 1980-87							
Total	152	9.724 (0.689)	11.898 (0.935)	16.889 (1.294)	-50.184 (17.586)	9.034 (3.549)	2.610 (3.217)
High-Tech	24	9.418 (0.462)	11.381 (0.928)	17.864 (0.421)	-47.123 (14.823)	9.600 (2.680)	0.514 (6.305)
Med-Tech	56	9.917 (0.434)	11.889 (0.601)	17.454 (1.325)	-47.252 (14.286)	6.561 (3.269)	2.581 (2.975)
Low-Tech	72	9.675 (0.854)	12.077 (1.086)	16.125 (0.990)	-53.485 (20.185)	10.735 (2.895)	3.332 (0.516)
Post-Liberalisation Phase, 1988-96							
Total	171	10.283 (0.756)	12.387 (0.988)	17.302 (1.323)	-54.115 (19.702)	12.036 (2.716)	3.161 (0.890)
High-Tech	27	10.035 (0.511)	12.013 (0.927)	18.269 (0.655)	-50.125 (16.625)	11.676 (2.219)	3.697 (0.478)
Med-Tech	63	10.460 (0.698)	12.158 (0.588)	17.866 (1.418)	-51.070 (19.194)	10.671 (3.238)	3.060 (1.251)
Low-Tech	81	10.229 (0.839)	12.688 (1.161)	16.542 (0.934)	-57.812 (20.567)	13.217 (1.738)	3.060 (0.531)

6. Results

We carried out a large number of estimations (the OLS fixed effect, EY and DOLS) with different combinations of the explanatory variables. Here we only report the final results for EY and DOLS and the full set of variables. The EY estimation results are reported in Tables 3, 4 & 5, and the DOLS estimation results in Table 6.

TABLE 3 *Determinants of Labour Productivity, Full Period, 1980-96 (Engle-Yoo Estimation)*^{a, b}

1980-1996	Total	High-tech	Med-tech	Low-tech
<i>l</i>	0.552 (0.087)**	0.627 (0.142)**	0.489 (0.238)*	0.554 (0.116)**
<i>k-l</i>	0.049 (0.042)	0.110 (0.103)	0.228 (0.115)*	-0.014 (0.048)
<i>ks_m</i>	0.060 (0.056)	0.385 (0.140)**	0.118 (0.085)	-0.003 (0.093)
<i>ks_m × hn</i>	0.014 (0.004)**	0.014 (0.006)*	0.011 (0.008)	0.016 (0.005)**
<i>ks_x</i>	0.047 (0.015)**	-0.058 (0.035)	0.035 (0.026)	0.050 (0.026)
<i>f</i>	-0.007 (0.013)	0.018 (0.017)	-0.007 (0.027)	-0.215 (0.108)*
Observations	323	51	119	153
Sectors	19	3	7	9

^a Standard errors are in parentheses

^b * Significant at 5%, ** at 1%

TABLE 4 *Determinants of Labour Productivity, Pre-Liberalisation Phase, 1980-87 (Engle-Yoo Estimation)*^{a, b}

1980-87	Total	High-tech	Med-tech	Low-tech
<i>l</i>	0.354 (0.108)**	0.074 (0.285)	-0.310 (0.164)	0.400 (0.126)**
<i>k-l</i>	0.282 (0.045)**	0.272 (0.091)*	0.506 (0.103)**	0.212 (0.047)**
<i>ks_m</i>	-0.148 (0.048)**	-0.113 (0.093)	-0.126 (0.046)**	-0.268 (0.069)**
<i>ks_m × hn</i>	0.014 (0.004)**	0.010 (0.008)	0.005 (0.005)	0.019 (0.005)**
<i>ks_x</i>	-0.004 (0.017)	0.150 (0.046)**	-0.008 (0.014)	-0.019 (0.027)
<i>f</i>	-0.019 (0.009)*	-0.022 (0.016)	-0.027 (0.009)**	-0.135 (0.082)
Observations	152	24	56	72
Sectors	19	3	7	9

^a Standard errors are in parentheses

^b * Significant at 5%, ** at 1%

TABLE 5 *Determinants of Labour Productivity, Post-Liberalisation Phase, 1988-96 (Engle-Yoo Estimation) ^{a, b}*

1988-1996	Total	High-tech	Med-tech	Low-tech
<i>l</i>	0.297 (0.131) *	0.290 (0.176)	0.592 (0.293) *	0.207 (0.154)
<i>k-l</i>	-0.031 (0.040)	0.006 (0.092)	0.203 (0.102)	-0.094 (0.033) **
<i>ks_m</i>	0.311 (0.070) **	0.642 (0.127) **	0.374 (0.109) **	0.205 (0.091) *
<i>ks_m × hn</i>	0.018 (0.004) **	0.024 (0.005) **	0.033 (0.008) **	0.010 (0.004) *
<i>ks_x</i>	0.033 (0.024)	0.020 (0.038)	-0.076 (0.042)	0.096 (0.030) **
<i>f</i>	0.058 (0.060)	0.136 (0.095)	0.151 (0.082)	-0.010 (0.100)
Observations	171	27	63	81
Sectors	19	3	7	9

^a Standard errors are in parentheses

^b * Significant at 5%, ** at 1%

We have restricted the DOLS estimation to the full sample of observations for the total period the pre-and post-liberalisation phases. This is because, estimation of sub-samples for the three technology classes suffer from low degrees of freedom owing to the presence of the lagged and led values of the independent variables.

Under the DOLS estimation for the complete sample (Table 6, column one), the international knowledge stock resulting from imports (*ks_m*) turns out to be the second most important contributor to labour productivity in manufacturing, after returns to scale. Its coefficient points to the importance of imports in generating international knowledge spillovers. The conditional import spillover effect (the interaction term *ks_m × hn*) is also highly significant, but its coefficient is much lower.

Comparison of the results for the pre- and post-liberalisation phases provides very interesting insights into the Indonesian industrialisation process. During the pre-liberalisation phase, under both EY and DOLS, returns to scale and capital accumulation accounted for most of the increases in productivity. Though the DOLS estimation yields a

significantly positive coefficient for ks_m , the EGY estimation turns up a negatively significant coefficient for this variable. The contribution of $ks_m \times hn$ is significant under both estimation methods, but the value of its coefficient is lower than that of the variables l and $k-l$. The coefficient of the variable representing spillovers from exports, ks_x , is significant with positive sign only under DOLS.

TABLE 6 *Determinants of Labour Productivity*
(DOLS Estimation)^{a, b, c}

	Full Period	Pre-Liberalisation	Post-Liberalisation
l	0.280 (0.068)**	0.877 (0.239)**	0.221 (0.112)
$k-l$	-0.020 (0.027)	0.219 (0.050)**	-0.079 (0.033)*
ks_m	0.174 (0.038)**	0.222 (0.076)**	0.207 (0.087)*
$ks_m \times hn$	0.017 (0.003)**	0.021 (0.005)**	0.022 (0.004)**
ks_x	0.008 (0.011)	0.050 (0.020)*	0.030 (0.036)
f	-0.003 (0.009)	0.009 (0.013)	0.110 (0.098)
T	0.057 (0.009)**	-0.003 (0.022)	0.055 (0.016)**
d	-0.154 (0.089)		
Constant	5.945 (0.667)**	-1.556 (1.967)	6.060 (1.311)**
Observations	323	152	171
Sectors	19	19	19
R-squared	0.94	0.97	0.96
Adj R-squared	0.93	0.96	0.94

^a Standard errors (Newey-West corrected) are in parentheses

^b * Significant at 5%, ** at 1%

^c Results for the industry dummies, and the lagged and led variables are not reported.

In the post-liberalisation phase, spillovers from imports have become the most important determinant of productivity. Capital is no longer a significant contributor to productivity change. Scale remains significant, but its contribution is much less important than in the pre-liberalisation phase. Interestingly, in contrast to import spillovers,

spillovers from exports are not significant during this phase. It may be noted that a recent plant level study by Takii (2005), for about the same period (1990-1995), also fails to find any significant positive contribution of exports. The positive coefficient of the interaction variable between market concentration and knowledge stock from imports in all the three samples suggests that some degree of concentration is helpful for learning.

The results for the separate three technology classes (under EY estimation) indicate even more marked differences between knowledge spillovers from imports in the pre- and post liberalisation phases. In the pre-liberalisation phase, none of these two indirect knowledge stock variables have significant positive coefficients (an exception is a significant, but very low coefficient for $ks_{m \times hn}$ in the low-tech sector). In the post-liberalisation phase, all the coefficients are significant and positive. Spillover effects occur at all technology levels, but the coefficients are highest in the high-tech industries and lowest in the low-tech industries, which is consistent with our expectations concerning technology spillovers.

The results on ks_x are notable in that they offer a different perspective on spillovers. Unlike spillovers resulting from imports, those from exports are significant only in the low-technology sector. We may recall in this context that the export-led manufacturing growth during the post-liberalisation phase had an explicit thrust on resource- and labour-based comparative advantage. The fact that technology-intensive sectors have not so far generated significant technology spillovers from exports may both be the cause and effect of the persistence of 'low-tech' activities within relatively high technology industries.

In the DOLS estimation, exogenous productivity change (as proxied by time trend) also has a more important (and significant) contribution in the post liberalisation phase.

Much is already known about the relative inefficiency of inward looking industrialisation regimes. Our findings also indicate that less technological learning occurs under this regime. The inward-oriented policy regime has not been conducive to technological progress and international knowledge spillovers from imports.

Our results do not show any evidence for technology spillovers from FDI. The coefficients of variable f show no positive significance, and even show negative significance in some cases. Recall in this context the results of existing studies on Indonesian manufacturing, which points to the spillover contribution of FDI as ambiguous.

7. Conclusions

In this paper we examined the importance of international knowledge spillovers from imports and exports for productivity performance in the Indonesian manufacturing industries. Following the literature on international inter-industry spillovers in advanced economies and the literature on catch-up and appropriate technology with regard to developing economies, we formulated a novel measure of north-south knowledge spillovers through imports. We also put forward a measure to capture spillovers resulting from exports.

A major obstacle to the measurement of indirect international knowledge stocks resulting from imports in a developing country such as Indonesia is the absence of indicators on knowledge and technology flows such as patent citations or foreign technology contracts. To overcome this obstacle, we developed a new measure of the international indirect knowledge stock by weighting the industry-level R&D stock of

major trading partners of Indonesia (in the OECD region), first with the intensity of their exports to Indonesia, and then with a combination of an inter-industry measure of technological-distance (based on EPO patent citations) and a bilateral structural congruence index between the same industries (based on input-output data). In a similar spirit, we constructed the indirect international knowledge stocks resulting from exports. Here, we used the industry-level exports from Indonesia to each of the 10 OECD trading partners to weight the manufacturing R&D intensity of the latter countries.

It should be emphasised that further research is needed on the operationalisation of international knowledge flows. Our methods are rather indirect and round-about, especially with regard to constructing the knowledge stock resulting from imports. This measure may also present more than pure knowledge spillovers, as a transaction involving user producer relations may also generate other forms of (pecuniary) spillovers. The new knowledge stock variables developed in this study, however, have shown themselves to be valuable for the analysis of international knowledge flows, capable of generating interesting and plausible results.

The substantive results of this study can be summarised as follows:

1. Imports are important for learning. The significant coefficients for the variables measuring the indirect knowledge stock resulting from imports suggest that imports from the advanced economies are positively associated with technological learning in Indonesian manufacturing and that international technology spillovers have been taking place.
2. There is a clear association between technological learning and policy regime. This is indicated by the differences in the influence on productivity of the indirect knowledge

stock variables resulting from imports in the pre-liberalisation and the post-liberalisation phases. The post-liberalisation export-oriented policy regime provides a positive incentive structure for technological learning. In the import-substitution phase, the bulk of the improvements in labour productivity derive from capital deepening and economies of scale. In the post-liberalisation phase, only the scale factor is still operative, but it is less prominent than in the pre-liberalisation phase.

These findings are plausible in the light of our broader knowledge of Indonesian industrialisation. During the pre-reform phase, the focus was mainly on scale- and capital-intensive industrialisation, with firms facing little external competition. The opening up of the economy has changed the situation dramatically, exposing firms to international competition. This exerts pressures to enhance technology and engage in learning.

3. The contribution of technological learning from imports depends on the technological level of industries. In the post-liberalisation period, the greatest effects are found for the high-tech sector, with weaker effects in the medium-tech sector and the least effects in the low-tech sector.
4. The contribution of spillovers from exports is less important than the contribution from imports. Significant positive contributions from this variable are limited to the high-tech sector during the pre-liberalisation phase, and the low-tech sector during the post-liberalisation phase. It appears that the emphasis, since the late eighties, on 'low-tech' manufacturing activities exploiting Indonesia's cost-based comparative advantage has restricted the transmission of knowledge spillovers from foreign buyers. In this respect, upgrading into more technology-intensive activities, although

requiring major efforts, may bring forth greater knowledge spillovers to domestic exporters, sustaining in turn the process of technological upgrading itself.

5. Concentration in the domestic market has modest favourable effects on labour productivity.
6. The results of this paper, both with regard to the learning effects associated with imports and the connection between export-orientation and technological learning are in line with an assimilationist view of late industrialisation.

References

- Abramovitz, M. 1989, *Thinking About Growth*, Cambridge University Press, Cambridge.
- Amsden, A. 1989, *Asia's Next Giant: South Korea and Late Industrialization*, Oxford University Press, New York.
- Banerjee, A., Dolado, J., Galbraith, J. W., & Hendry, D. F. 1993, *Cointegration, Error Correction and the Econometric Analysis of Non-Stationary Data*, Oxford University Press, Oxford.
- Basant, R. & Fikkert, B. 1996, "The effects of R&D, foreign technology purchase and domestic and international spillovers on productivity in Indian firms", *Review of Economics and Statistics*, 78(2), 187-199.
- Basu, S & Weil, D. N. 1998 "Appropriate Technology and Growth", *Quarterly Journal of Economics*, 113(4), 1025-1054.
- Bresnahan, T. (1986), "Measuring the Spillovers from Technical Advance: Mainframe Computers in Financial Services", *American Economic Review* 76(4): 742-55.
- Cohen, W. M., & Levin, R. 1989, "Empirical Studies of Innovation and Market Structure," in *Handbook of Industrial Organization*, vol. 2, Elsevier, Amsterdam, pp. 1059-1107.
- Coe, D. T., & Helpman, E. 1995, "International R&D spillovers", *European Economic Review*, 39 (5), 859–887.
- Coe, D. T., Helpman, E., & Hoffmaister, A. W. 1999, "North-South R&D Spillovers", *The Economic Journal*, vol. 107, pp. 134-149.

- Engle, R.F. & Yoo, B.S., 1991. "Cointegrated Economic Time Series: A Survey With New Results," in *Long Run Economic Relationships*, R. F. Engle, & C. Granger, eds., Oxford University Press, Oxford.
- Goeltom, M. *Indonesia's Financial Liberalization. An Empirical Analysis of 1981-1988 Panel Data*. 1995. Institute of South East Asian Studies, Singapore.
- Griliches, Z. 1979, "Issues in Assessing the Contribution of R&D to Productivity Growth", *The Bell Journal of Economics*, vol. 10, pp. 92-116.
- Hikino, T. & Amsden, A. H. 1994, "Staying Behind, Stumbling Back, Sneaking Up, Soaring Ahead: Late Industrialization in Historical Perspective," in *Convergence of Productivity*, W. J. Baumol, R. R. Nelson, & E. N. Wolff, eds., Oxford University Press, Oxford and New York, pp. 283-315.
- Hill, H. 1988, *Foreign Investment and Industrialization in Indonesia*, Oxford University Press, Singapore.
- Hill, H. 1995, "Indonesia's Great Leap Forward? Technology Development and Policy Issues", *Bulletin of Indonesian Economic Studies*, vol. 31, no. 2, pp. 83-123.
- Hill, H., 1996, *The Indonesian Economy since 1966*, Cambridge University Press, Cambridge.
- Hill H. and Thee, K. W. (eds) 1998, *Indonesia's Technological Challenge*, ANU, ISAS.
- Im, K. S., Pesaran, M. H. & Shin, Y. 2003, "Testing for Unit Roots in Heterogeneous Panels", *Journal of Econometrics*, vol. 115, pp. 53-74.
- Jaffe, A. B. 1986, "Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits, and Market Value", *American Economic Review*, vol. 76, pp. 984-1001.

- Jammal, Y. "Backcasting Manufacturing Growth", 1975-1990. DPS Statistical Paper: 1993. BPS/DPS, Jakarta.
- Kathuria, V. 2002, "Liberalisation, FDI and productivity spillovers- An analysis of Indian manufacturing firms", *Oxford Economic Papers*, 54, 688-718
- Kiely, R. 1998, *Industrialisation and Development. A Comparative Analysis*, UCL Press, London.
- Kim, L. 1997, *Imitation to Innovation: The Dynamics of Korea's Technological Learning*, Harvard Business School Press, Boston.
- Kim, L. 1999, *Learning and Innovation in Economic Development*, Edward Elgar, Cheltenham.
- Kim, L. and R.R. Nelson (eds) (2000), *Technology, Learning and Innovation. Experiences of Newly Industrialising Economies*, CUP, Cambridge.
- Krugman, P. R. 1994, "The Myth of Asia's Miracle", *Foreign Affairs*, vol. 73, no. 6, pp. 62-78.
- Lall, S, 1982, 'Technological Learning in the Third World: Some Implications of Technology Exports', in F. Stewart and J. James (eds), *The Economics of New Technology in Developing Countries*, London: Frances Pinter.
- Lall, S. 1998, "Technology Policies in Indonesia," in *Indonesia's Technological Challenge*, H. Hill, & K. W. Thee, eds., ANU, ISAS.
- Lichtenberg, F. R. & Bruno van Pottelsberghe de la Potterie 1998, "International R&D Spillovers: A Comment", *European Economic Review*, vol. 42, no. 8, pp. 1483-1491.
- Los, B. 1999, *The Impact of Research & Development on Economic Growth and Structural Change*, Unpublished PhD thesis, University of Twente.

- Los, B. & Verspagen, B. 2000, "R&D Spillovers and Productivity: Evidence from U.S. Manufacturing Microdata", *Empirical Economics*, vol. 25, pp. 127-148.
- Nelson, R. & Pack, H. 1999, "The Asian Miracle and Modern Growth Theory", *The Economic Journal*, pp. 416-436.
- Pearson, C.S. (1994), 'The Asian Export Ladder', in S. Yang (ed.), *Manufactured Exports of East Asian Industrializing Economies: Possible Regional Cooperation*, M.E. Sharp, New York: 35-52.
- Rodrik, D. "TFPG Controversies, Institutions and Economic Performance in East Asia", 1997. NBER Working Paper No.5914.
- Romer, P. M. 1987, "Growth Based on Increasing Returns Due to Specialization", *American Economic Review*, vol. 77, no. 2, pp. 56-62.
- Saikkonen, P. 1991, "Asymptotically Efficient Estimation of Cointegration Regression", *Econometric Theory*, vol. 7, pp.1-21.
- Sjöholm, F. 1999, Technology Gap, Competition and Spillovers from Direct Foreign Investment: Evidence From Establishment Data, *Journal of Development Studies*, Vol. 36, no.1, pp. 53-73.
- Takii, S. 2005, "Productivity Spillovers and Characteristics of Foreign Multinational Plants in Indonesian Manufacturing 1990–1995", *Journal of Development Economics*, vol. 76, no. 2, pp. 521-42.
- Thee, K. W. 1991, "The Surge of Asian NIC Investment to Indonesia", *Bulletin of Indonesian Economic Studies*, vol. 27, no. 3, pp. 55-88.
- Thee, K.W. 2003, "The Major Channels of International Technology Transfer to Indonesia: An Assessment", Paper presented at the Conference on Catch-Up Growth

and Technology Transfer, Groningen Centre for Growth and Development, University of Groningen, 17-18 October.

Timmer, M. 2000, *The Dynamics of Asian Manufacturing. A Comparison in the late Twentieth Century*, Edward Elgar, Cheltenham.

van Meijl, H. & van Tongeren, F. 1999, "Endogenous International Technology Spillovers and Biased Technical Change in Agriculture", *Economic Systems Research*, vol. 11, no. 1, pp. 31-48.

Verspagen, B. 1997, "Estimating International Technology Spillovers Using Technology Flow Matrices", *Weltwirtschaftliches Archiv*, vol. 133, no. 2.

von Hippel, E. 1988, *The Sources of Innovation.*, Oxford University Press: New York.

Westphal, L. E., Kim, L., & Dahlman, C. 1985, "Reflections on Korea's Acquisition of Technological Capability," in *International Technology Transfer*, N. Rosenberg & C. Frischtak, eds., Praeger, New York.

Young, A. 1994, "Lessons from the East Asian Growth NIEs: A Contrarian View", *European Economic Review*, vol. 38, no. 3-4, pp. 964-973.

Appendix Tables

TABLE A.1 *Determinants of Labour Productivity, Full Period, 1980-96 (OLS Within-Industry Estimate)*^{a, b, c}

1980-96	Total	High-tech	Med-tech	Low-tech
<i>l</i>	0.238 (0.067)**	0.356 (0.231)	0.040 (0.204)	0.136 (0.084)
<i>k-l</i>	0.040 (0.022)	0.064 (0.053)	0.024 (0.070)	0.039 (0.023)
<i>ks_m</i>	0.113 (0.031)**	0.269 (0.151)	0.211 (0.050)**	-0.057 (0.049)
<i>ks_m×hn</i>	0.013 (0.002)**	0.011 (0.006)	0.015 (0.004)**	0.013 (0.003)**
<i>ks_x</i>	0.013 (0.009)	-0.001 (0.051)	-0.016 (0.016)	0.026 (0.014)
<i>f</i>	-0.006 (0.007)	0.006 (0.018)	-0.023 (0.017)	0.049 (0.055)
<i>T</i>	0.038 (0.007)**	0.012 (0.024)	0.058 (0.017)**	0.053 (0.010)**
<i>d</i>	0.023 (0.075)	0.130 (0.192)	0.096 (0.144)	0.002 (0.093)
Constant	6.286 (0.560)**	3.768 (2.383)	6.250 (1.360)**	9.172 (0.870)**
Sectors	19	3	7	9
Observations	323	51	119	153
R-squared	0.92	0.89	0.86	0.96
Adj. R-squared	0.91	0.86	0.84	0.95

^a Standard errors are in parentheses; ^b * Significant at 5%, ** at 1%; ^c Estimates for the industry dummies are not reported.

TABLE A.2 *Determinants of Labour Productivity, Pre-Liberalisation Phase, 1980-87(OLS Within-Industry Estimates)*^{a, b, c}

1980-87	Total	High-tech	Med-tech	Low-tech
<i>l</i>	0.441 (0.163)**	1.827 (1.058)	-0.095 (0.353)	-0.221 (0.244)
<i>k-l</i>	0.246 (0.038)**	0.316 (0.192)	0.411 (0.138)**	0.201 (0.040)**
<i>ks_m</i>	-0.072 (0.045)	0.021 (0.180)	-0.076 (0.063)	-0.123 (0.068)
<i>ks_m×hn</i>	0.011 (0.004)**	0.014 (0.016)	0.003 (0.007)	0.020 (0.005)**
<i>ks_x</i>	-0.005 (0.013)	-0.066 (0.090)	-0.012 (0.017)	-0.010 (0.022)
<i>f</i>	-0.016 (0.008)*	-0.006 (0.029)	-0.021 (0.012)	0.050 (0.089)
<i>T</i>	-0.011 (0.014)	-0.107 (0.055)	-0.006 (0.024)	0.070 (0.026)**
Constant	5.670 (1.295)**	1.595 (5.640)	6.318 (2.548)*	11.193 (1.958)**
Sectors	19	3	7	9
Observations	152	24	56	72
R-squared	0.94	0.90	0.88	0.97
Adj. R-squared	0.93	0.84	0.85	0.96

^a Standard errors are in parentheses; ^b * Significant at 5%, ** at 1%; ^c Estimates for the industry dummies are not reported.

TABLE A.3 *Determinants of Labour Productivity, Post-Liberalisation Phase, 1988-96 (OLS Within-Industry Estimates)*^{a, b, c}

1988-96	Total	High-tech	Med-tech	Low-tech
<i>l</i>	0.221 (0.117)	-0.104 (0.306)	-0.444 (0.314)	0.029 (0.153)
<i>k-l</i>	-0.007 (0.029)	0.056 (0.047)	0.009 (0.089)	-0.069 (0.029)*
<i>ks_m</i>	0.185 (0.070)**	0.043 (0.296)	0.296 (0.091)**	0.102 (0.101)
<i>ks_m×hn</i>	0.020 (0.003)**	0.025 (0.007)**	0.037 (0.006)**	0.012 (0.003)**
<i>ks_x</i>	0.008 (0.023)	0.176 (0.097)	-0.087 (0.033)*	0.074 (0.032)*
<i>f</i>	0.098 (0.060)	0.119 (0.112)	0.164 (0.095)	0.048 (0.082)
<i>T</i>	0.048 (0.014)**	0.101 (0.053)	0.128 (0.031)**	0.042 (0.017)*
Constant	5.886 (1.085)**	7.473 (4.526)	8.757 (2.436)**	8.004 (1.456)**
Sectors	19	3	7	9
Observations	171	27	63	81
R-squared	0.93	0.93	0.92	0.97
Adj. R-squared	0.92	0.89	0.90	0.97

^a Standard errors are in parentheses; ^b * Significant at 5%, ** at 1%; ^c Estimates for the industry dummies are not reported.



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